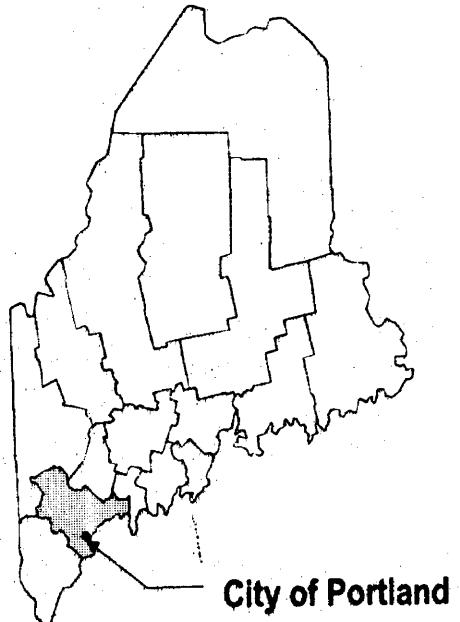


# FLOOD INSURANCE STUDY



**CITY OF  
PORTLAND  
AND TOWN OF  
LONG ISLAND,  
MAINE  
CUMBERLAND COUNTY**



REVISED:  
DECEMBER 8, 1998



**Federal Emergency Management Agency**

COMMUNITY NUMBERS  
230051-City of Portland  
231035-Town of Long Island

**NOTICE TO  
FLOOD INSURANCE STUDY USERS**

Communities participating in the National Flood Insurance Program have established repositories of flood hazard data for floodplain management and flood insurance purposes. This Flood Insurance Study (FIS) may not contain all data available within the repository. It is advisable to contact the community repository for any additional data.

Part or all of this FIS may be revised and republished at any time. In addition, part of this FIS may be revised by the Letter of Map Revision process, which does not involve republication or redistribution of the FIS. It is, therefore, the responsibility of the user to consult with community officials and to check the community repository to obtain the most current FIS components.

Selected Flood Insurance Rate Map panels for this community contain information that was previously shown separately on the corresponding Flood Boundary and Floodway Map panels (e.g., floodways and cross sections). In addition, former flood hazard zone designations have been changed as follows:

<u>Old Zones</u>	<u>New Zone</u>
A1 through A30	AE
V1 through V30	VE
B	X
C	X

Initial FIS Effective Date: July 17, 1986

Revised FIS Dates: July 15, 1992 (Flood Insurance Rate Map only)  
December 8, 1998

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**FLOOD INSURANCE STUDY**  
**CITY OF PORTLAND AND TOWN OF LONG ISLAND, CUMBERLAND COUNTY, MAINE**

## **1.0 INTRODUCTION**

### **1.1 Purpose of Study**

This Flood Insurance Study (FIS) revises and updates a previous FIS/Flood Insurance Rate Map (FIRM) for the City of Portland and Town of Long Island, Cumberland County, Maine, hereinafter referred to collectively as the City of Portland. This information will be used by the City of Portland to update existing floodplain regulations as part of the Regular Phase of the National Flood Insurance Program (NFIP). The information will also be used by local and regional planners to further promote sound land use and floodplain development.

In some States or communities, floodplain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence and the State (or other jurisdictional agency) will be able to explain them.

### **1.2 Authority and Acknowledgments**

The sources of authority for this FIS are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

For the original July 17, 1986, FIS, the hydrologic and hydraulic analyses were prepared in several phases. The initial analyses of riverine and stillwater flooding were performed under a joint venture by Anderson-Nichols & Co., Inc.; Camp Dresser & McKee/Resource Analysis; and New England Coastal Engineers for the Federal Emergency Management Agency (FEMA), under Contract No. H-4771. The initial work was completed in November 1979. A modification to the contract in September 1982 called for the analysis of the impacts of wave heights and wave runup on flooding. The updated work was performed under the joint venture of Anderson-Nichols & Co., Inc., and Camp Dresser & McKee/Resource Analysis for FEMA. The updated work was completed in September 1983.

For this revision, the revised hydrologic and hydraulic analyses for Capisic Brook and new analyses for East Branch Capisic Brook and West Branch Capisic Brook were prepared by the Natural Resource Conservation Service (NRCS) for the City of Portland; this work was completed in November 1995. Also, the revised analyses for Fall Brook were prepared by Green International Affiliates, Inc., for FEMA, under Contract No. EMB-96-CO-0403, Task Order No. 2. This work was completed in June 1997. Finally, a revision to the hydrologic and hydraulic analyses for Capisic Brook, from the upstream side of Capisic Pond Dam to Warren Avenue, was prepared by the Natural Resource Conservation Service, in response to a request by the City of Portland. The results of the analyses were provided to FEMA in January 1996.

### **1.3 Coordination**

The purpose of an initial Consultation Coordination Officer's (CCO) meeting is to discuss the scope of the FIS. A final CCO meeting is held to review the results of the study.

For the July 17, 1986, FIS, an initial CCO meeting was held on April 19, 1978, and was attended by representatives of the city, FEMA, and the joint venture of Anderson-Nichols & Co., Inc.; Camp Dresser & McKee/Resource Analysis; and New England Coastal Engineers. Pertinent information was obtained from the U.S. Geological Survey (USGS), Stone and Webster Engineering Corporation, community officials, the Maine Department of Transportation, the Greater Portland Council of Governments, the U.S. Army Corps of Engineers (USACE), and the National Oceanic and Atmospheric Administration (NOAA). A final CCO meeting was held on November 29, 1984, and was attended by representatives of Anderson-Nichols & Co., Inc., the city, and FEMA.

For this revision, an intermediate CCO meeting for the restudy of Fall Brook was held on September 5, 1996, and was attended by representatives of Green International Affiliates, Inc., the city, and FEMA.

## 2.0 AREA STUDIED

### 2.1 Scope of Study

This FIS covers the incorporated area of the City of Portland, Cumberland County, Maine. The area of study is shown on the Vicinity Map (Figure 1).

For the July 17, 1986, FIS, the riverine flooding of the Presumpscot River, the Stroudwater River, Fall Brook, Capisic Brook, and Nasons Brook; and the tidal flooding including its wave action of Casco Bay, the Fore River, and Back Cove were studied by detailed methods. Several areas of shallow flooding on the eastern shores of several of the Portland Island were included in the detailed tidal analysis.

For this revision, the following flooding sources were restudied or newly studied by detailed methods: Fall Brook, from Back Cove to a point just upstream of Allen Street; Capisic Brook, from the upstream side of Capisic Pond Dam to Warren Avenue; East Branch Capisic Brook, from its confluence with Capisic Brook to a point approximately 2,500 feet upstream; and West Branch Capisic Brook, from its confluence with Capisic Brook to the Maine Turnpike. Also, this revision corrects a previous mislabeling of Capisic Brook in the vicinity of Warren Avenue.

This revision also incorporates the effects of a July 7, 1997, Letter of Map Revision, Case No. 97-01-033P, for the East Side Interceptor project.

Limits of detailed study are indicated on the Flood Profiles (Exhibit 1) and on the Flood Boundary and Floodway Map (FBFM) or the revised FIRM (Exhibit 2). The areas studied by detailed methods were selected with priority given to all known flood hazard areas and areas of projected development and proposed construction.

All or portions of the following streams were studied by approximate methods: Long Creek, several unnamed tributaries, the Stroudwater River, Nasons Brook, and East Branch Capisic Brook. Approximate analyses were used to study those areas having a low development potential or minimal flood hazards. The scope and methods of study were proposed to, and agreed upon by, FEMA and the city.

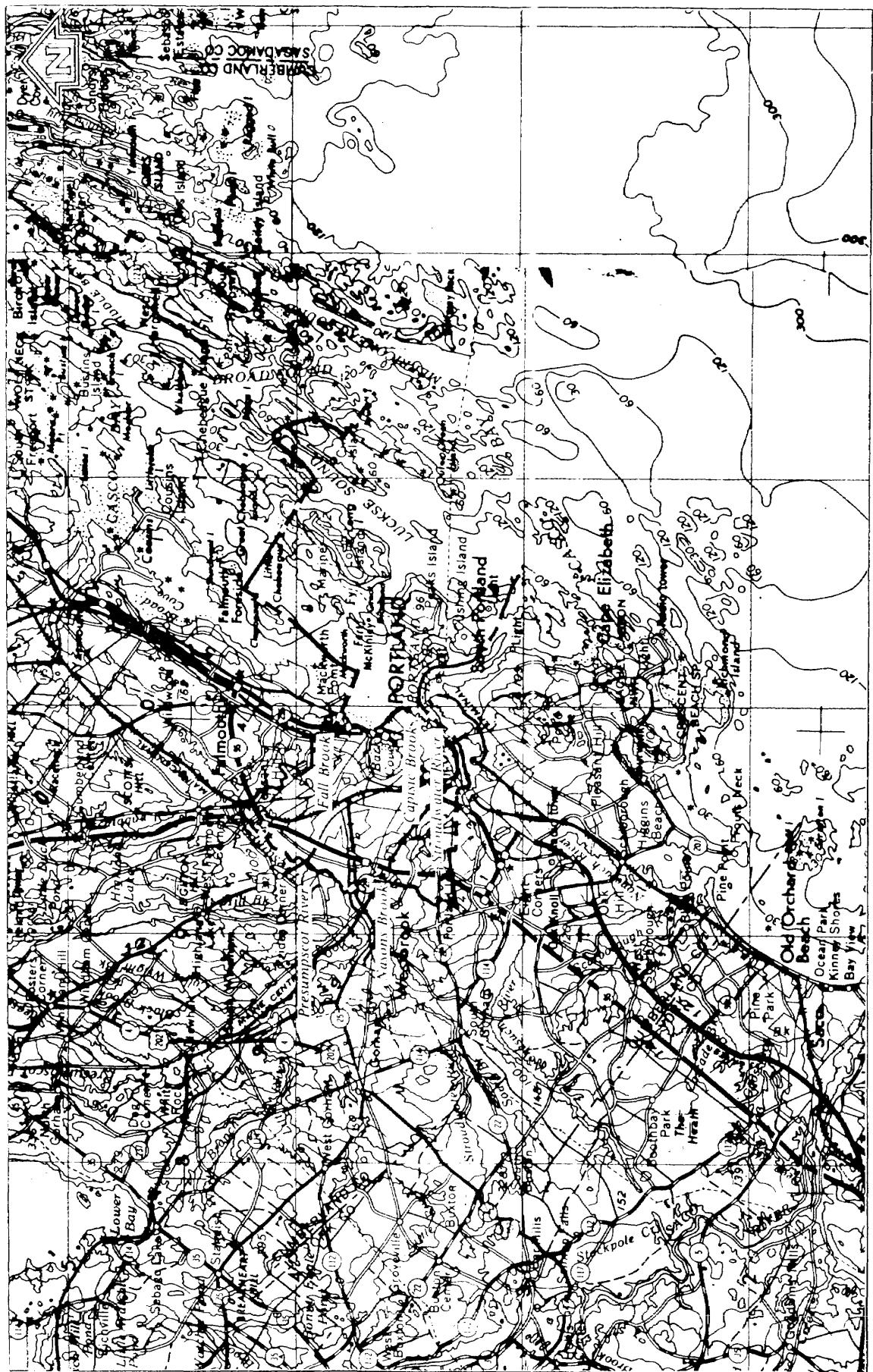
# VICINITY MAP

APPROXIMATE SCALE  
12 MILES  
4  
0  
8  
4  
0

## CITY OF PORTLAND, ME (CUMBERLAND CO.)

FEDERAL EMERGENCY MANAGEMENT AGENCY

FIGURE 1



## 2.2 Community Description

The City of Portland is located in the southeastern portion of Cumberland County in southern Maine, approximately 100 miles north of the City of Boston. It is bordered by the Towns of Falmouth and Cumberland to the north, the City of Westbrook to the west, the City of South Portland to the south, The Town of Cape Elizabeth to the southwest, and Casco Bay to the east. The total land area contained within the corporate limits of Portland is 21.6 square miles. The 1990 population of the city was estimated to be 64,358.

The climate in the area is moderate. The mean annual temperature is 45 degrees Fahrenheit ( $^{\circ}$ F). Temperatures range from an average of 21.8 $^{\circ}$ F in January to an average of 68.1 $^{\circ}$ F in July. Rainfall averages 42.9 inches annually, and the average annual snowfall is 74.6 inches.

The terrain of the city varies from sea level along the coast and the Fore River to areas reaching a maximum elevation of 160 feet. Topographical features in the area are the result of glacial deposition in some areas and removal of bedrock in others. The material deposited by the glaciers consists of clay, sand, and silt.

The watersheds of the Stroudwater River, Fall Brook, Capisic Brook, and Nasons Brook are predominantly residential with scattered industrial development. The area along the Presumpscot River is devoted to major public and institutional use. The properties along the Fore River and the Atlantic Coast are predominantly commercial and industrial. Development on the Portland Islands is mainly residential, but Long Island has major industrial development.

## 2.3 Principal Flood Problems

Each year, the City of Portland experiences severe coastal storms commonly referred to as northeasters. In the past, hurricanes have caused extreme high tides and flooding of low-lying areas along the coast and the Fore River. The northeasters can occur at any time of the year but are more prevalent in the winter months, whereas hurricanes occur in the late summer and early fall months.

Tide levels along the coastline of the City of Portland are greatly influenced by the force, duration, and direction of winds as well as the distance across open water, or fetch, over which these winds act. A northeaster produces high tides along the Portland coastline. The storm of record occurred in February 1978, and damage occurred along the coast, the Fore River, and Back Cove.

## 2.4 Flood Protection Measures

The City of Portland has regulations which apply to construction in areas of flood hazard. The regulations call for modifications "to prevent flotation, collapse, or lateral movement of the structure." Structural flood protection measures along the coast are limited.

There is a non-functioning power dam on the Presumpscot River that provides minimal flood protection. The Presumpscot River is regulated to some degree by dams further upstream in Westbrook. These dams were originally designed to provide power; flood protection is an added benefit. The steep banks of the Presumpscot River and the large storage capacity of Lake Sebago provide natural flood protection along the river.

### 3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this FIS. Flood events of a magnitude which are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10-, 2-, 1-, and 0.2-percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (1-percent chance of annual exceedence) in any 50-year period is approximately 40 percent (4 in 10), and, for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this FIS. Maps and flood elevations will be amended periodically to reflect future changes.

#### 3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for the flooding source studied in detail affecting the community.

For the July 17, 1986, FIS, discharges for the Presumpscot River were obtained from the FIS for the City of Westbrook (Reference 1). These discharges were transposed to the proper drainage areas for the City of Portland using the following formula:

$$Q/Q_g = (A/A_g)^{0.8}$$

where Q and  $Q_g$  are the discharges at the station and the gage, respectively, and A and  $A_g$  are the drainage areas at these locations.

For the Stroudwater River, discharges were obtained from the Soil Conservation Service (now the NRCS) flood hazard analyses for the river (Reference 2). The 10-, 100-, and 500-year discharges were given, and the 50-year discharge was interpolated.

Discharges for Capisic Brook, from its confluence with the Fore River to Warren Avenue, and Nasons Brook were determined using a regional equation developed by the USGS (Reference 3). This equation relates streamflow to the parameters of drainage area, main channel slope, and percent storage available. The 10-, 50-, and 100-year discharges at several stations on the streams were calculated. The 500-year discharge at each station was extrapolated from a log-normal plot of the three calculated flow values.

For this revision, discharges for Fall Brook were computed using the USACE HEC-1 computer program (Reference 4). Discharges for Capisic Brook, East Branch Capisic Brook and West Branch Capisic Brook were computed using the NRCS TR-20 computer program (Reference 5).

A summary of the drainage area-peak discharge relationships for all streams studied by detailed methods is shown in Table 1, "Summary of Discharges."

TABLE 1 - SUMMARY OF DISCHARGES

<u>FLOODING SOURCE AND LOCATION</u>	<u>DRAINAGE AREA (sq. miles)</u>	<u>PEAK DISCHARGES (cfs)</u>			
		<u>10-YEAR</u>	<u>50-YEAR</u>	<u>100-YEAR</u>	<u>500-YEAR</u>
<b>PRESUMPSCOT RIVER</b>					
Downstream of the confluence of the Piscataqua River	632.2	9,800	13,600	15,300	19,700
Upstream of the confluence of the Piscataqua River	590.9	9,300	12,900	14,500	18,600
<b>STROUDWATER RIVER</b>					
At the upstream corporate limits	27.2	1,885	3,100	3,735	5,160
<b>FALL BROOK</b>					
Near its confluence with Back Cove	1.60	288	433	498	657
Upstream of Washington Avenue	0.60	114	131	142	171
At Ray Street	0.27	110	121	128	144
<b>CAPISIC BROOK</b>					
At its confluence with the Fore River	5.09	620	890	1,020	1,310
Upstream of confluence of Nasons Brook	2.78	539	804	935	1,337
At Essex Road (extended)	1.92	498	724	835	1,075

TABLE 1 - SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs)			
		10-YEAR	50-YEAR	100-YEAR	500-YEAR
<b>NASONS BROOK</b>					
Upstream of the confluence of Capisic Brook	1.43	180	270	330	440
Near Portland Terminal Railroad culvert	1.15	125	195	225	310
<b>EAST BRANCH CAPISTIC BROOK</b>					
At its confluence with Capisic Brook	0.35	191	315	370	521
<b>WEST BRANCH CAPISTIC BROOK</b>					
At its confluence with Capisic Brook	0.56	340	447	485	601

The water level recorder at the City of Portland makes relatively continuous records of tidal surge levels available. Because of the differences in topography and bathymetry in coastal Portland, numerical models were used to tie the gaging records to all areas of the Portland coastline. Two major models were used to calculate the surge created by a storm on the open coast. These models have been extensively tested and are the standard models used for coastal FIS in northern New England.

The stillwater elevations for this FIS were generated using a two-dimensional storm surge model (Reference 6). This model used a modified version of the FEMA storm surge model (References 7 and 8). The model was first run for the Atlantic Ocean off the Maine coast to the entrance of Casco Bay with grid segments of 4 nautical miles. The same model was then run for Casco Bay using smaller grid segments of 1 nautical mile, which provided sufficient resolution to accurately represent the topography.

Input to the model consisted of wind and pressure fields generated either by the synthetic northeaster model or a hurricane wind and pressure field for each historic storm selected. Output from the model included the time history of storm-induced water elevations in the area. These elevations were combined with the predicted astronomical tide for the same period to produce a total stillwater elevation for each community in the study area.

The model was calibrated in Casco Bay using some of the high-water marks for the February 1978 northeaster. Bathymetric depths were then adjusted in the model to tune to the observed data at five points. Twenty storms were simulated, each considering astronomical tides, northeastern model storm tracks (storm surge developed from synthetic wind and pressure fields), surge model boundaries in Casco Bay, and initial rise estimates. A statistical regression analysis was performed on the resulting

simulations to correlate the storm tide elevations (STE) at 38 different points in Casco Bay to the Portland STE. Next, the historic record of annual maximum STE at the Portland gage was analyzed using the log-Pearson Type III distribution as a model. The statistical analysis program was then applied to the 38 points in Casco Bay giving stillwater elevations for 10-, 50-, 100-, and 500-year frequency storms.

The philosophy behind this approach to the evaluation of coastal stillwater elevations is that reliable estimates for Portland can be obtained by an analysis of the historic record. Estimates at other locations can then be obtained by creating a synthetic record based on relationships (linear regression) between STE's at these locations and the two historic records. The modeling results are only used to form the basis for the regression analysis.

Five high-water marks were obtained from the USGS for the February 1978 northeaster and are shown in Table 2, "High-Water Mark Elevations" (Reference 9).

TABLE 2 - HIGH-WATER MARK ELEVATIONS

<u>LOCATION</u>	<u>ELEVATION (feet NGVD)</u>
Back Cove	9.91
Marine Wharf	9.43
Peaks Wharf	9.84
State Route 9 bridge north of the Stroudwater River	9.39
At Burnham and Morrill Canning Factory	9.55

Due to the complexity and length of the Fore River and Back Cove systems and the lack of water level information for the upper portions of the systems, it was decided to apply a one-dimensional storm surge model for tidal rivers and inlets to obtain relationships between flood levels near the beach and those further inland (Reference 10).

Tide and depth data and channel cross-section information were taken for several points on each of these systems from NOAA maps, USGS topographic maps, and tide tables (References 11, 12, and 13).

Boundary conditions for the model (winds and surge heights) were calculated using the northeaster model and the ocean storm surge models mentioned above. Calibration of the model was performed by referring to recorded high-water marks from the February 1978 northeaster (Reference 9). This storm was chosen because of the availability of accurate data, and since it was one of the strongest storms on record.

Through the use of the one-dimensional model, it was found that the 100-year flood elevations for the Fore River range from 9.5 feet at the mouth to 10.1 feet at the

Congress Street Bridge. The 100-year flood elevations for Back Cove range from 9.4 feet at the mouth to 9.8 feet in both the northwest and southwest quadrants.

The stillwater elevations for the 10-, 50-, 100-, and 500-year floods have been determined for Casco Bay, the Fore River, and Back Cove and are shown in Table 3, "Summary of Stillwater Elevations."

TABLE 3 - SUMMARY OF STILLWATER ELEVATIONS

FLOODING SOURCE AND LOCATION	ELEVATION (feet NGVD)			
	10-YEAR	50-YEAR	100-YEAR	500-YEAR
<b>CASCO BAY</b>				
Martin Point	8.6	9.2	9.5	10.0
Fish Point	8.7	9.3	9.5	10.1
At Pumpkin Nob on Peaks Island	8.6	9.2	9.4	10.0
At City Point on Peaks Island	8.6	9.1	9.4	9.9
Eastern side of Peaks Island	8.6	9.1	9.4	9.9
Western side of Cushings Island	8.5	9.1	9.3	9.9
Eastern side of Cushings Island	8.6	9.1	9.4	9.9
Eastern side of House Island	8.5	9.1	9.3	9.8
Western side of House Island	8.6	9.2	9.4	10.0
Great Diamond Island	8.6	9.2	9.4	10.0
Western side of Little Diamond Island	8.6	9.2	9.4	9.9
Eastern side of Little Diamond Island	8.6	9.2	9.4	10.0
Northern side of Long Island	8.5	9.1	9.3	9.9
Southern side of Long Island	8.4	9.0	9.2	9.7
Western side of Long Island	8.5	9.1	9.4	9.9
Northeastern side of Cliff Island	8.5	9.1	9.3	9.9
Southeastern side of Cliff Island	8.5	9.0	9.3	9.8
Western side of Cliff Island	8.5	9.1	9.4	9.9
Jewell Island	8.5	9.0	9.3	9.8
<b>FORE RIVER</b>				
At its mouth	8.7	9.3	9.5	10.1
State Pier	8.7	9.4	9.6	10.1
Coast Guard Base (South Portland)	8.8	9.5	9.7	10.3
Portland Bridge	8.9	9.6	9.8	10.4
Veterans Memorial Bridge	8.9	9.6	9.8	10.4
Thompson Point	9.1	9.9	10.2	10.9
Congress Street Bridge	9.1	9.8	10.1	10.8
<b>BACK COVE</b>				
Casco Bay outlet and north shore	8.6	9.2	9.4	10.0
West, south, and east shores	8.9	9.5	9.8	10.4

The analyses reported in this FIS reflect the stillwater elevations due to tidal and wind setup effects. The effects of wave action were also considered in the determination of flood hazard areas. Coastal structures that are located above stillwater flood elevations can still be severely damaged by wave runup, wave-induced erosion, and wave-borne debris. For example, during the northeaster of February 1978, considerable damage along the Maine coast was caused by wave activity, even though most of the damaged structures were above the high-water level. The extent of wave runup past stillwater levels depends greatly on the wave conditions and local topography.

Wave heights and corresponding wave crest elevations were determined using the National Academy of Sciences (NAS) methodology (Reference 14). The wave runup was determined using the methodology developed by Stone and Webster Engineering Corporation for FEMA (Reference 15).

### 3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the source/sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals.

For the July 17, 1986, FIS, overbank portions of cross-section data were obtained from topographic maps (Reference 16); below-water sections were obtained by field survey. Cross sections were located at close intervals above and below bridges in order to compute the significant backwater effects of these structures. In long reaches between structures, appropriate valley cross sections were also surveyed.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 4.2), selected cross section locations are also shown on the FBFM or the revised FIRM (Exhibit 2).

For the 1986 FIS, water-surface elevations of floods of the selected recurrence intervals were computed using the USACE HEC-2 step-backwater computer program (Reference 17). Flood profiles were drawn showing computed water-surface elevations for floods of the selected recurrence intervals. Starting water-surface elevations for the Presumpscot River were obtained from the FIS for the Town of Falmouth (Reference 18). Starting water-surface elevations for the Stroudwater River, Fall Brook, Capisic Brook, and Nasons Brook were determined using the mean tide elevation.

For this revision, water-surface elevations of floods of the selected recurrence intervals were computed for Fall Brook using the USACE HEC-2 step-backwater computer program; and for Capisic Brook, East Branch Capisic Brook, and West Branch Capisic Brook, using the NRCS WSP2 step-backwater computer program (References 19 and 20).

Roughness factors (Manning's "n") used in the hydraulic computations were assigned on the basis of field inspection. The channel "n" and overbank "n" values for all streams studied by detailed methods are shown in the following tabulation:

<u>Stream</u>	<u>Channel "n"</u>	<u>Overbank "n"</u>
Presumpscot River	0.050	0.065-0.120
Stroudwater River	0.030-0.040	0.040-0.080
Fall Brook	0.030-0.055	0.030-0.140
Capisic Brook	0.035-0.060	0.055-0.120
Nasons Brook	0.025-0.040	0.040-0.080
East Branch Capisic Brook	0.035-0.060	0.055-0.120
West Branch Capisic Brook	0.035-0.060	0.055-0.120

The hydraulic analyses for this FIS were based on unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

Hydraulic analyses, considering storm characteristics and the shoreline and bathymetric characteristics of the tidal flooding sources studied, were carried out to provide estimates of the elevations of floods of the selected recurrence intervals along each of the shorelines.

Areas of coastline subject to significant wave attack are referred to as coastal high hazard zones. The USACE has established the 3-foot breaking wave as the criterion for identifying the limit of coastal high hazard zones (Reference 21). The 3-foot wave has been determined as the minimum size wave capable of causing major damage to conventional wood frame or brick veneer structures,

A wave height analysis was performed to determine wave heights and corresponding wave crest elevations for the areas inundated by the tidal flooding. A wave runup analysis was performed to determine the height and extent of runup beyond the limit of tidal inundation. The results of these analyses were combined into a wave envelope, which was constructed by extending the maximum wave runup elevation seaward to its intersection with the wave crest profile.

The methodology for analyzing wave heights and corresponding wave crest elevations was developed by the NAS (Reference 14). The NAS methodology is based on three major concepts.

First, a storm surge on the open coast is accompanied by waves. The maximum height of these waves is related to the depth of water by the following equation:

$$H_b = 0.78d$$

where  $H_b$  is the crest to trough height of the maximum or breaking wave and  $d$  is the stillwater depth. The elevation of the crest of an unimpeded wave is determined using the equation:

$$Z_w = S^* + 0.7H^* = S^* + 0.55d$$

where  $Z_w$  is the wave crest elevation,  $S^*$  is the stillwater elevation at the site, and  $H^*$  is the wave height at the site. The 0.7 coefficient is the portion of the wave height which reaches above the stillwater elevation.  $H_b$  is the upper limit for  $H^*$ .

The second major concept is that the breaking wave height may be diminished by dissipation of energy by natural or man-made obstructions. The wave height transmitted past a given obstruction is determined by the following equation:

$$H_t = BH_i$$

where  $H_t$  is the transmitted wave height,  $H_i$  is the incident wave height, and  $B$  is a transmission coefficient ranging from 0.0 to 1.0. The coefficient is a function of the physical characteristics of the obstruction. Equations have been developed by the NAS to determine  $B$  for vegetation, buildings, natural barriers such as dunes, and man-made barriers such as breakwaters and seawalls (Reference 14).

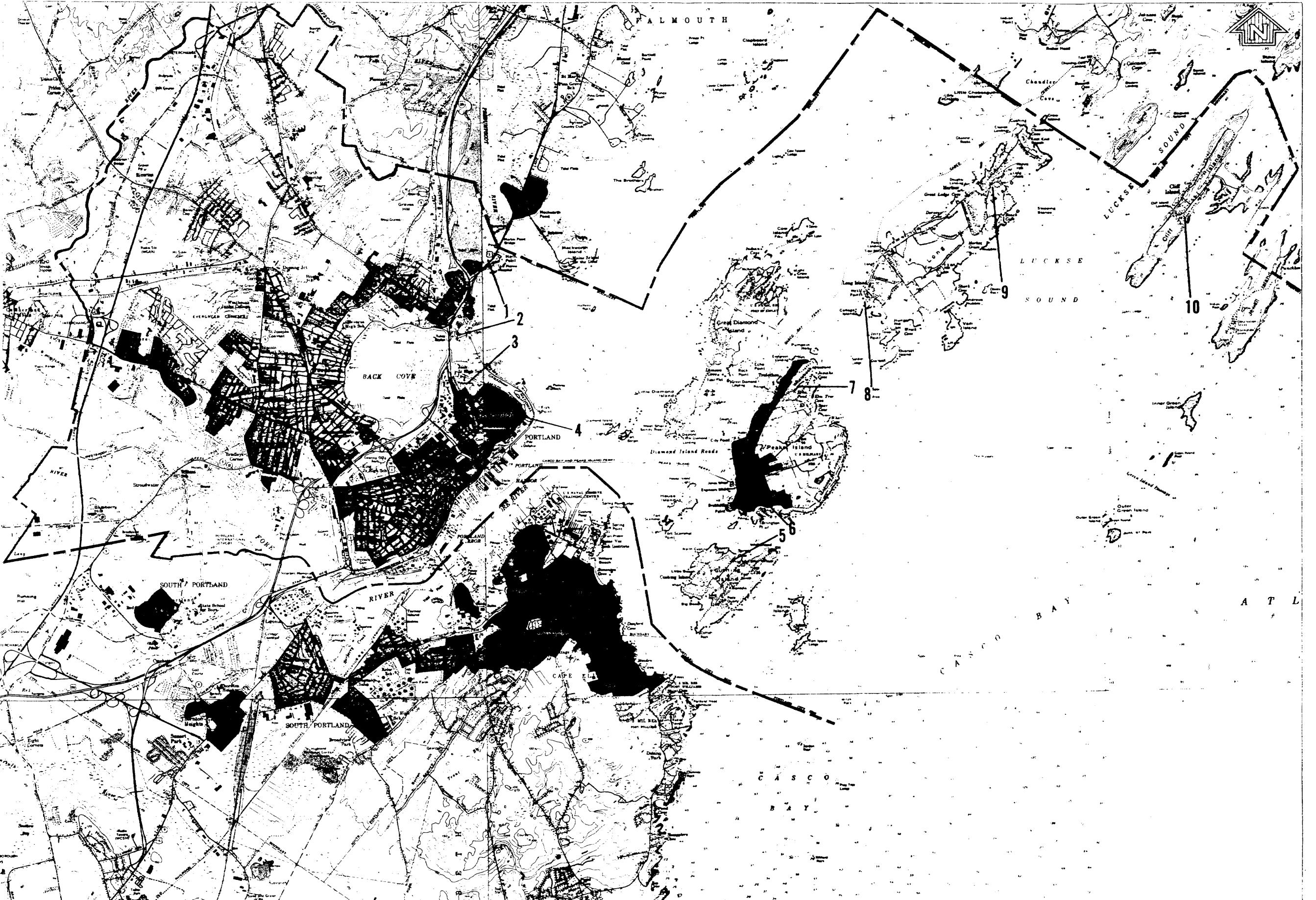
The third concept deals with unimpeded reaches between obstructions. New wave generation can result from wind action. This added energy is related to distance and mean depth over the unimpeded reach.

The methodology for analyzing wave runup was developed by Stone and Webster Engineering Corporation (Reference 15). The wave runup computer program operates using an ensemble of deepwater wave heights,  $H_i$ , the stillwater elevation,  $S^*$ , a wave period,  $T_s$ , and beach slope,  $m$ . For Portland, wave heights range from 2 feet up to a maximum wave height of 20.8 feet; the wave periods range from 2.1 to 10.3 seconds.

These concepts and equations were used to compute wave envelope elevations associated with the 100-year storm surge. Accurate topographic, land-use, and land cover data are required for the coastal analyses. Maps of the study area, at a scale of 1:4,800 with a contour interval of 5 feet were used for the topographic data (Reference 16). The land-use and land cover data were obtained by field surveys.

Wave heights and wave runup were computed along transects which were located perpendicular to the average mean shoreline. The transects were located with consideration given to the physical and cultural characteristics of the land so that they would closely represent conditions in their locality. Transects were spaced close together in areas of complex topography and dense development. In areas having more uniform characteristics, the transects were spaced at larger intervals.

It was also necessary to locate transects in areas where unique flooding existed and in areas where computed wave heights varied significantly between adjacent transects. Figure 2, "Transect Location Map," illustrates the location of the transects for the community.



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FIGURE 2

APPROXIMATE SCALE

15,000 FEET

TRANSECT LOCATION MAP

Along each transect, wave envelope elevations were computed considering the combined effects of changes in ground elevation, vegetation, and physical features. Between transects, elevations were interpolated using the topographic maps, land-use and land cover data, and engineering judgment to determine the areal extent of flooding. The results of the calculations are accurate until local topography, vegetation, or cultural development within the community undergo any major changes.

Areas of shallow flooding have been determined for the lee side of the berms along Casco Bay. In these areas, the wave runup elevation exceeded the dune crest elevation. The difference between the runup elevation and the dune crest was used to determine the depth of shallow flooding behind the dune (Reference 22).

Areas of ponding have been determined along Massachusetts Bay and Beverly Harbor. In these areas, the wave runup elevation exceeded the bluff elevation. The amount of overtopping and flooding behind the bluff were determined based on the bluff elevation and surrounding topography (References 22 and 23).

Delineation of flooding for small portions of Mackworth and Hope Islands was taken from the FISs for the Towns of Falmouth and Cumberland, respectively (References 18 and 24).

Figure 3, "Transect Schematic," represents a sample transect that illustrates the relationship between stillwater elevation, the wave crest elevation, the ground elevation profile, and the location of the V/A zone boundary.

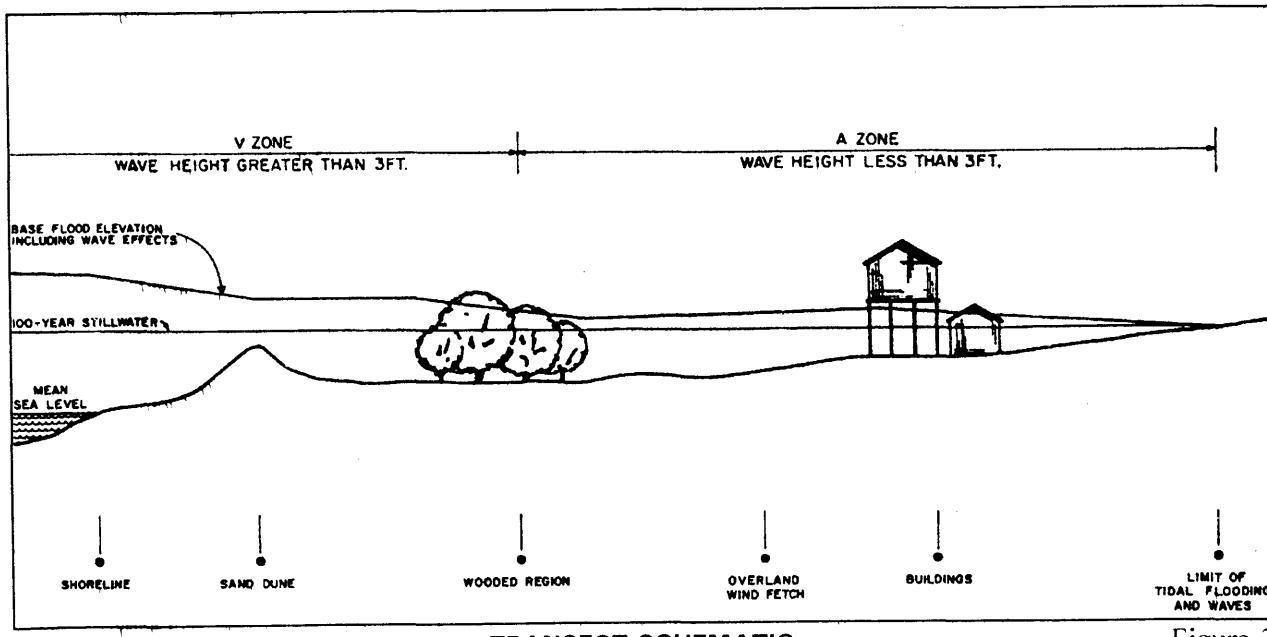


Figure 3

All elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD). Elevation reference marks used in this study, and their descriptions, are shown on the FIRM.

#### 4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

The NFIP encourages State and local governments to adopt sound floodplain management programs. Therefore, each FIS generally provides 100-year flood elevations and delineations of the 100- and 500-year floodplain boundaries and 100-year floodway to assist in developing floodplain management measures.

##### 4.1 Floodplain Boundaries

To provide a national standard without regional discrimination, the 1-percent annual chance (100-year) flood has been adopted by FEMA as the base flood for floodplain management purposes. The 0.2-percent annual chance (500-year) flood is employed to indicate additional areas of flood risk in the community. For the streams studied in detail, the 100- and 500-year floodplains have been delineated using the flood elevations determined at each cross section. For the 1986 FIS, the boundaries were interpolated between cross sections using topographic maps at a scale of 1:4,800 with a contour interval of 5 feet (Reference 16). For this revision, the boundaries were interpolated between cross sections using topographic maps at a scale of 1:1,200 with a contour interval of 2 feet (Reference 25).

For the flooding sources studied by approximate methods, the 100-year floodplain boundaries were delineated using USGS topographic maps and the Flood Hazard Boundary Map for the city (Reference 12).

The 100- and 500-year floodplain boundaries are shown on the FBFM and the FIRM (Exhibit 2). On these maps, the 100-year floodplain boundary corresponds to the boundary of the areas of special flood hazards (Zones A and AE), and the 500-year floodplain boundary corresponds to the boundary of areas of moderate flood hazards. In cases where the 100- and 500-year floodplain boundaries are close together, only the 100-year floodplain boundary has been shown. Small areas within the floodplain boundaries may lie above the flood elevations but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

For the streams studied by approximate methods, only the 100-year floodplain boundary is shown on the FBFM and the FIRM (Exhibit 2).

## 4.2 Floodways

Encroachment on floodplains, such as structures and fill, reduces flood-carrying capacity, increases flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of floodplain management involves balancing the economic gain from floodplain development against the resulting increase in flood hazard. For purposes of the NFIP, a floodway is used as a tool to assist local communities in this aspect of floodplain management. Under this concept, the area of the 100-year floodplain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent floodplain areas, that must be kept free of encroachment so that the 100-year flood can be carried without substantial increases in flood heights. Minimum Federal standards limit such increases to 1.0 foot, provided that hazardous velocities are not produced. The floodway in this study is presented to local agencies as a minimum standard that can be adopted directly or that can be used as a basis for additional floodway studies.

The floodways presented in this FIS was computed for certain stream segments on the basis of equal conveyance reduction from each side of the floodplain. Floodway widths were computed at cross sections. Between cross sections, the floodway boundaries were interpolated. The results of the floodway computations are tabulated for selected cross sections (Table 4). The computed floodways are shown on the FBFM and the FIRM (Exhibit 2). In cases where the floodway and 100-year floodplain boundaries are either close together or collinear, only the floodway boundary is shown. Portions of the floodway for the Presumpscot River extend beyond the corporate limits. No floodways were computed for East Branch Capisc Brook and West Branch Capisc Brook.

Encroachment into areas subject to inundation by floodwaters having hazardous velocities aggravates the risk of flood damage, and heightens potential flood hazards by further increasing velocities. A listing of stream velocities at selected cross sections is provided in Table 4, "Floodway Data." To reduce the risk of property damage in areas where the stream velocities are high, the community may wish to restrict development in areas outside the floodway.

Near the mouths of streams studied in detail, floodway computations are made without regard to flood elevations on the receiving water body. Therefore, "Without Floodway" elevations presented in Table 4 for certain downstream cross sections of the Stroudwater River, Fall Brook, Capisc Brook, and Nasons Brook are lower than the regulatory flood elevations in that area, which must take into account the 100-year flooding due to backwater from other sources.

The area between the floodway and 100-year floodplain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the floodplain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood by more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 4.

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	1 WIDTH (FEET)	2 SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY FLOODWAY	WITHOUT FLOODWAY	WITH FLOODWAY (FEET NGVD)	INCREASE
Presumpscot River								
A	18,454	164/90	2,610	5.9	22.3	22.3	22.4	0.1
B	19,515	190/80	2,666	5.7	23.5	23.5	23.7	0.2
C	27,931	180/124	3,385	4.3	31.7	31.7	32.4	0.7
D	29,251	315/250	4,827	3.0	32.2	32.2	33.0	0.8
E	30,677	303/53	5,054	2.9	32.6	32.6	33.5	0.9
F	32,307	724/695	7,800	1.9	32.8	32.8	33.7	0.9
G	34,667	779/240	8,781	1.7	33.1	33.1	34.1	1.0
H	35,657	541/361	5,855	2.5	33.2	33.2	34.2	1.0
I	36,557	800/620	8,401	1.7	33.4	33.4	34.4	1.0
J	37,777	797/65	6,006	2.4	33.6	33.6	34.6	1.0
K	38,867	164/75	3,931	3.7	33.7	33.7	34.6	0.9
L	39,907	423/100	4,396	3.3	34.3	34.3	35.1	0.8
M	40,467	462/380	8,894	1.6	34.7	34.7	35.5	0.8
N	41,577	461/255	7,139	2.0	34.8	34.8	35.6	0.8
O	42,487	271/155	4,668	3.1	34.8	34.8	35.6	0.8
P	43,407	274/60	3,991	3.6	34.9	34.9	35.7	0.8
Q	45,257	864/610	5,906	2.5	35.4	35.4	36.3	0.9

<sup>1</sup>Feet above confluence with Casco Bay  
<sup>2</sup>width/width within corporate limits

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### FLOODWAY DATA

### PRESUMPSCOT RIVER

FLOODING SOURCE		FLOODWAY				BASE FLOOD WATER SURFACE ELEVATION (FEET NGVD)		
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Stroudwater River	A	0.036 <sup>1</sup>	60	655	5.7	10.1	4.3 <sup>3</sup>	5.3
	B	0.096 <sup>1</sup>	75	601	6.2	13.9	13.9	0.0
	C	0.117 <sup>1</sup>	98	1,148	3.3	25.1	25.1	0.0
	D	0.204 <sup>1</sup>	76	914	4.1	25.1	25.1	0.0
	E	0.305 <sup>1</sup>	60	752	5.0	25.7	25.7	0.0
	F	0.621 <sup>1</sup>	67	850	4.4	26.4	26.6	0.2
	G	1.015 <sup>1</sup>	125	1,310	2.9	26.9	27.8	0.9
Fall Brook	A	222 <sup>2</sup>	41	232	2.1	6.3	6.7	0.4
	B	742 <sup>2</sup>	12	45	11.1	9.6	9.7	0.1
	C	1,382 <sup>2</sup>	10	164	2.9	29.9	30.1	0.2
	D	1,847 <sup>2</sup>	20	232	2.0	29.9	30.2	0.3
	E	2,147 <sup>2</sup>	59	446	1.1	29.9	30.5	0.6
	F	2,367 <sup>2</sup>	54	360	0.9	30.0	30.6	0.6
	G	2,547 <sup>2</sup>	114	963	0.3	32.6	33.1	0.5
	H	3,042 <sup>2</sup>	73	370	0.8	32.7	33.3	0.6
	I	3,436 <sup>2</sup>	13	40	7.8	35.2	35.3	0.1
	J	4,111 <sup>2</sup>	6	33	4.3	49.3	49.7	0.4
	K	5,191 <sup>2</sup>	21	58	2.4	53.3	54.2	0.9
	L	5,811 <sup>2</sup>	30	64	2.2	55.9	55.9	0.0

<sup>1</sup>Miles above confluence with Fore River

<sup>2</sup>Feet above confluence with Back Cove

<sup>3</sup>Elevation computed without consideration of backwater effects from Fore River  
<sup>4</sup>Elevation computed without consideration of backwater effects from Back Cove

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## FLOODWAY DATA

### STROUDWATER RIVER - FALL BROOK

**TABLE 4**

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION (FEET NGVD)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Fall Brook (continued)								
M	6,386 <sup>1</sup>	7	34	3.7	57.9	58.6	58.6	0.7
N	7,588 <sup>1</sup>	34	98	1.3	61.4	61.7	61.7	0.3
O	8,183 <sup>1</sup>	14	35	7.7	66.7	66.7	66.7	0.0
P	8,883 <sup>1</sup>	120	196	1.4	69.7	69.7	69.7	0.0
Q	9,388 <sup>1</sup>	264	283	0.8	70.1	70.5	70.5	0.4
Capisic Brook								
A	0.025 <sup>2</sup>	220	1,810	0.6	10.1	5.2 <sup>3</sup>	6.0	0.8
B	0.203 <sup>2</sup>	356	1,558	0.7	10.1	5.2 <sup>3</sup>	6.0	0.8
C	0.230 <sup>2</sup>	400	1,045	1.0	10.1	5.3 <sup>3</sup>	6.1	0.8
D	0.338 <sup>2</sup>	742	2,566	0.4	10.1	5.4 <sup>3</sup>	6.2	0.8
E	0.368 <sup>2</sup>	266	1,943	0.5	10.3	10.3	10.3	0.0
F	0.504 <sup>2</sup>	90	572	1.2	10.3	10.3	10.3	0.0
G	0.580 <sup>2</sup>	121	902	0.8	34.1	34.1	34.1	0.0
H	0.629 <sup>2</sup>	81	713	1.0	36.3	36.3	36.3	0.0
I	0.838 <sup>2</sup>	142	1,198	0.6	36.3	36.3	36.3	0.0
J	0.974 <sup>2</sup>	38	289	2.4	36.3	36.2	36.2	0.0

<sup>1</sup>Feet above confluence with Back Cove

<sup>2</sup>Miles above confluence with Fore River

<sup>3</sup>Elevation computed without consideration of backwater effects from Fore River

TABLE 4

**CITY OF PORTLAND, ME  
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**FLOODWAY DATA**

**FALL BROOK - CAPISTIC BROOK**

FLOODING SOURCE		FLOODWAY			BASE FLOOD			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY FLOODWAY (FEET NGVD)	WITHOUT FLOODWAY (FEET NGVD)	WITH FLOODWAY (FEET NGVD)	INCREASE
Capisic Brook (continued)								
K	1.1491	18	110	4.6	37.0	37.0	37.1	0.1
L	1.2401	17	166	3.0	40.2	40.2	40.6	0.4
M	1.3621	70	390	1.3	40.3	40.3	40.8	0.5
N	1.4101	53	325	1.5	42.0	42.0	42.1	0.1
O	1.4871	148	741	0.7	42.0	42.0	42.2	0.2
P	1.5551	61	425	1.2	43.7	43.7	43.7	0.0
Q	1.6901	43	225	2.2	43.8	43.8	43.9	0.1
R	1.8761	10	73	6.9	46.0	46.0	46.0	0.0
S	1.9421	194	876	0.6	46.0	46.0	46.8	0.8
T	2.0511	71	453	0.6	49.1	49.1	49.9	0.8
U	2.2951	96	264	0.9	49.1	49.1	50.0	0.9
V	2.6551	55	217	1.2	52.2	52.2	52.7	0.5
Nasons Brook								
A	0.0122	40	227	1.5	10.2	4.53	5.5	1.0
B	0.3172	28	133	2.5	10.2	4.73	5.7	1.0
C	0.9492	14	91	3.3	10.2	6.43	7.1	0.7
D	1.3022	102	262	1.1	10.2	7.23	8.2	1.0
E	1.3512	20	31	7.2	42.8	42.8	42.9	0.1
F	1.4082	20	79	2.8	44.2	44.2	44.7	0.5
G	1.4572	15	50	4.5	45.4	45.4	45.7	0.3

<sup>1</sup>Miles above confluence with Fore River

<sup>2</sup>Miles above confluence with Capisic Brook

<sup>3</sup>Elevation computed without consideration of backwater from Capisic Brook

**CITY OF PORTLAND, ME**  
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## FLOODWAY DATA

CAPISIC BROOK AND NASONS BROOK

FEDERAL EMERGENCY MANAGEMENT AGENCY

**TABLE 4**

FLOODING SOURCE		FLOODWAY			BASE FLOOD			
CROSS SECTION	DISTANCE <sup>1</sup>	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY (FEET NGVD)	WITH FLOODWAY (FEET NGVD)	INCREASE
Nasons Brook (continued)								
H	1.480	25	79	2.8	45.6	45.6	46.3	0.7
I	1.650	22	109	2.1	50.6	50.6	50.6	0.0
J	1.763	4	31	7.3	54.1	54.1	54.1	0.0

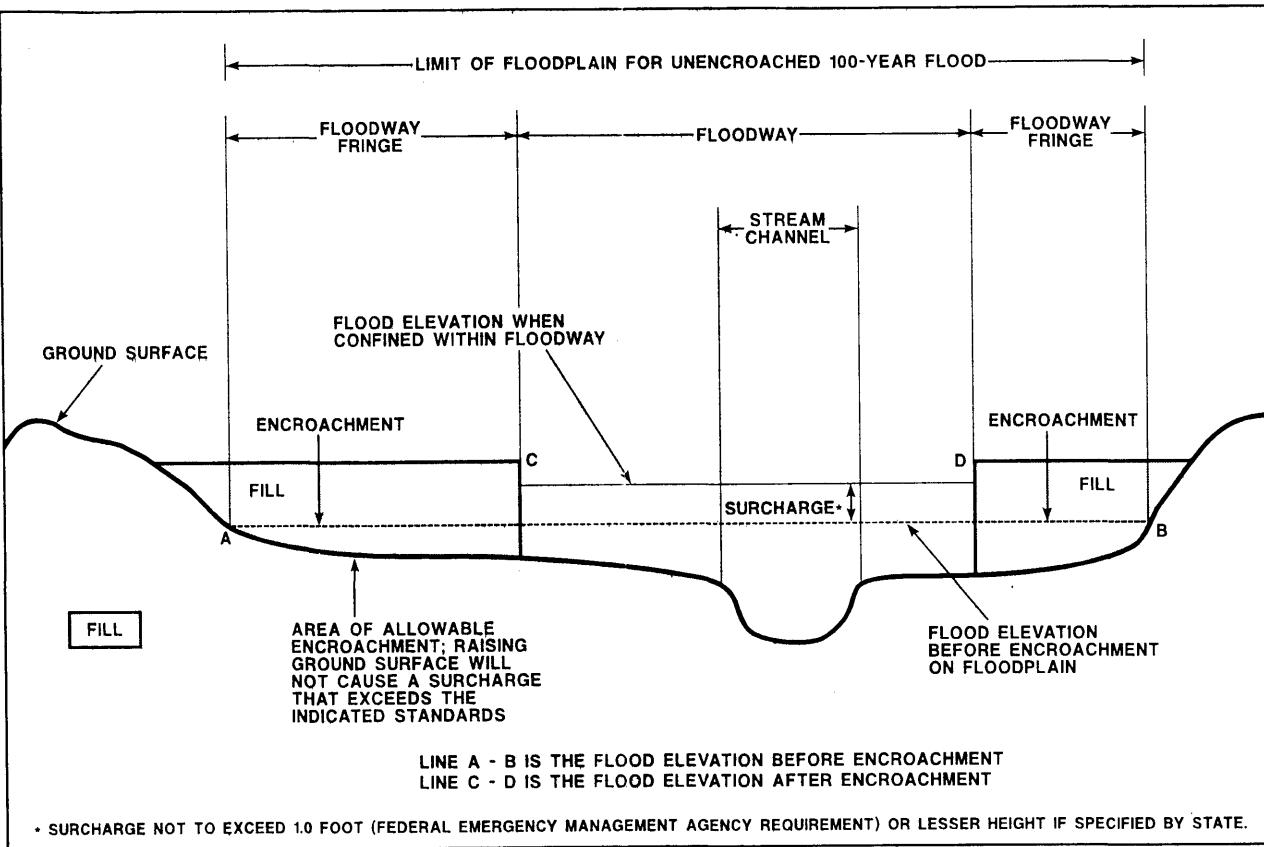
<sup>1</sup>Miles above confluence with Capisic Brook

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY  
**CITY OF PORTLAND, ME**  
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**FLOODWAY DATA**

**NASON'S BROOK**



**FLOODWAY SCHEMATIC**

Figure 4

## 5.0 INSURANCE APPLICATIONS

For flood insurance rating purposes, flood insurance zone designations are assigned to a community based on the results of the engineering analyses. The zones are as follows:

### Zone A

Zone A is the flood insurance rate zone that corresponds to the 100-year floodplains that are determined in the FIS by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no base flood elevations or depths are shown within this zone.

### Zone AE (includes Zones A1 through A30)

Zone AE is the flood insurance rate zone that corresponds to the 100-year floodplains that are determined in the FIS by detailed methods. In most instances, whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

#### Zone AH

Zone AH is the flood insurance rate zone that corresponds to the areas of 100-year shallow flooding (usually areas of ponding) where average depths are between 1 and 3 feet. Whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

#### Zone AO

Zone AO is the flood insurance rate zone that corresponds to the areas of 100-year shallow flooding (usually sheet flow on sloping terrain) where average depths are between 1 and 3 feet. Average whole-depths derived from the detailed hydraulic analyses are shown within this zone.

#### Zone A99

Zone A99 is the flood insurance rate zone that corresponds to areas of the 100-year floodplain that will be protected by a Federal flood protection system where construction has reached specified statutory milestones. No base flood elevations or depths are shown within this zone.

#### Zone V

Zone V is the flood insurance rate zone that corresponds to the 100-year coastal floodplains that have additional hazards associated with storm waves. Because approximate hydraulic analyses are performed for such areas, no base flood elevations are shown within this zone.

#### Zone VE (includes Zones V1 through V30)

Zone VE is the flood insurance rate zone that corresponds to the 100-year coastal floodplains that have additional hazards associated with storm waves. Whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

#### Zone X (includes Zones B and C)

Zone X is the flood insurance rate zone that corresponds to areas outside the 500-year floodplain, areas within the 500-year floodplain, and to areas of 100-year flooding where average depths are less than 1 foot, areas of 100-year flooding where the contributing drainage area is less than 1 square mile, and areas protected from the 100-year flood by levees. No base flood elevations or depths are shown within this zone.

#### Zone D

Zone D is the flood insurance rate zone that corresponds to unstudied areas where flood hazards are undetermined, but possible.

## **6.0 FLOOD INSURANCE RATE MAP**

The FIRM is designed for flood insurance and floodplain management applications.

For flood insurance applications, the map designates flood insurance rate zones as described in Section 5.0 and, in the 100-year floodplains that were studied by detailed methods, shows selected whole-foot base flood elevations or average depths. Insurance agents use the zones and base flood elevations in conjunction with information on structures and their contents to assign premium rates for flood insurance policies.

For floodplain management applications, the map shows by tints, screens, and symbols, the 100- and 500-year floodplains. On selected FIRM panels, floodways and the locations of selected cross sections used in the hydraulic analyses and floodway computations are shown where applicable. Floodways are shown on the FBFM where they are not shown on the FIRM.

## **7.0 OTHER STUDIES**

For Fall Brook, information regarding the East Side Interceptor was taken from CSO studies prepared by the USACE; Hunter-Ballew Associates; and the State of Maine, Department of Transportation (References 26, 27 and 28).

FISs have been prepared for the Cities of South Portland and Westbrook and the Towns of Cape Elizabeth, Cumberland, and Falmouth (References 29, 1, 30, 24, and 18).

Because it is based on more up-to-date analyses, this FIS supersedes the previously printed FIS for the City of Portland (Reference 31).

## **8.0 LOCATION OF DATA**

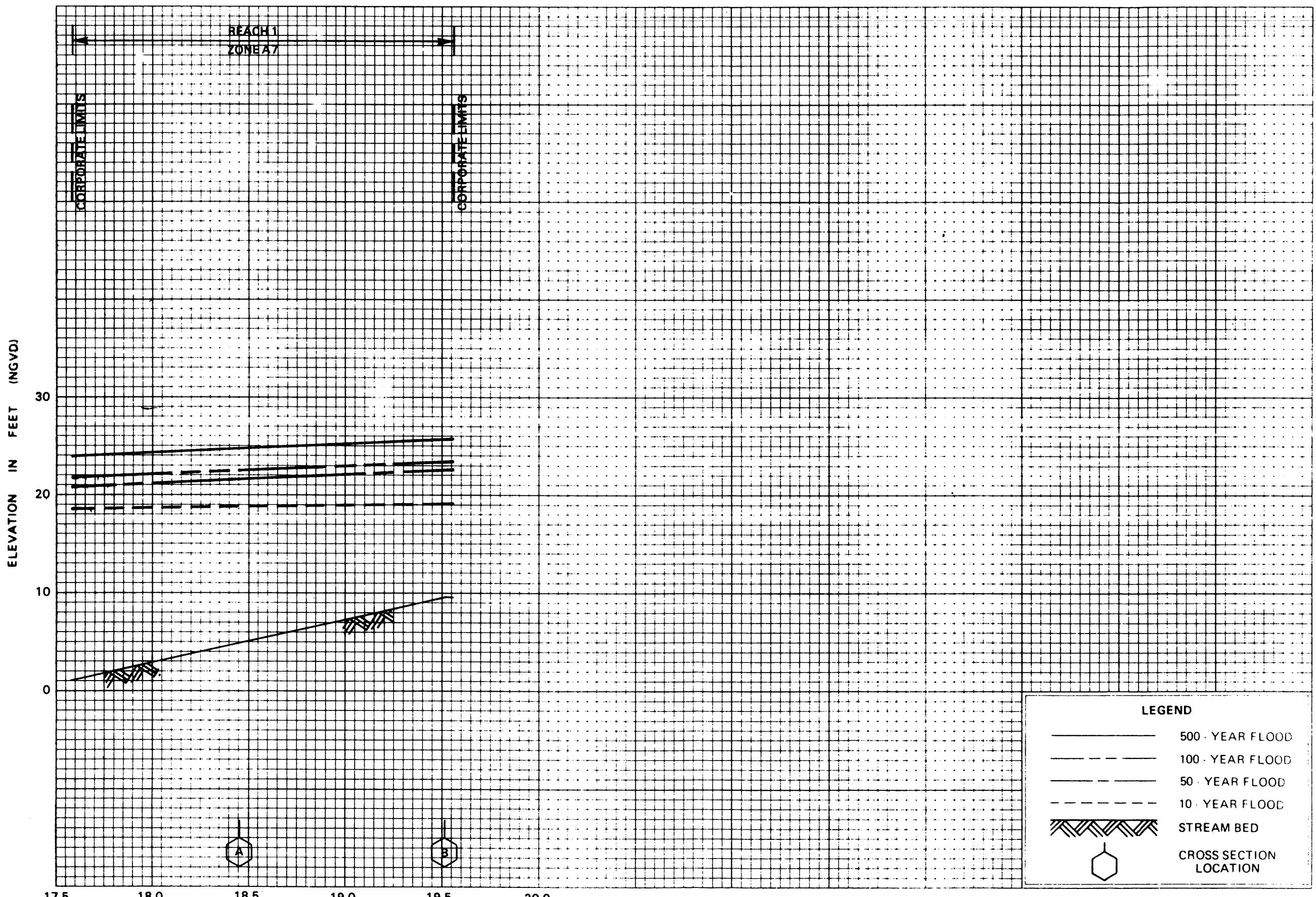
Information concerning the pertinent data used in preparation of this study can be obtained by contacting FEMA, the Mitigation Division, J. W. McCormack Post Office and Courthouse Building, Room 462, Boston, Massachusetts 02109.

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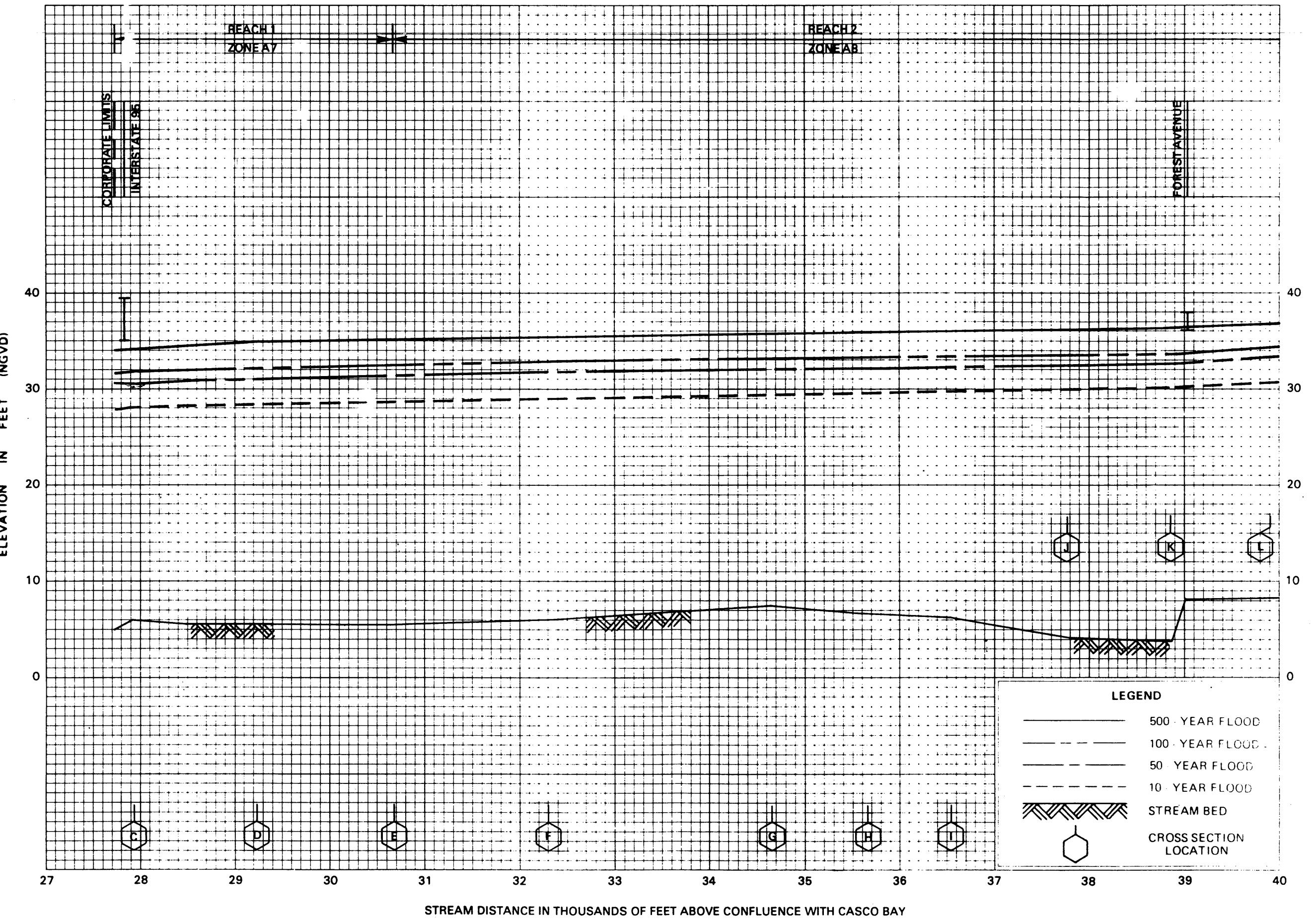
**FLOOD PROFILES**  
**PRESUMPSCOT RIVER**

# PRESUMPSCOT RIVER

## FLOOD PROFILES

CITY OF PORTLAND, ME  
(CUMBERLAND CO.)

FEDERAL EMERGENCY MANAGEMENT AGENCY

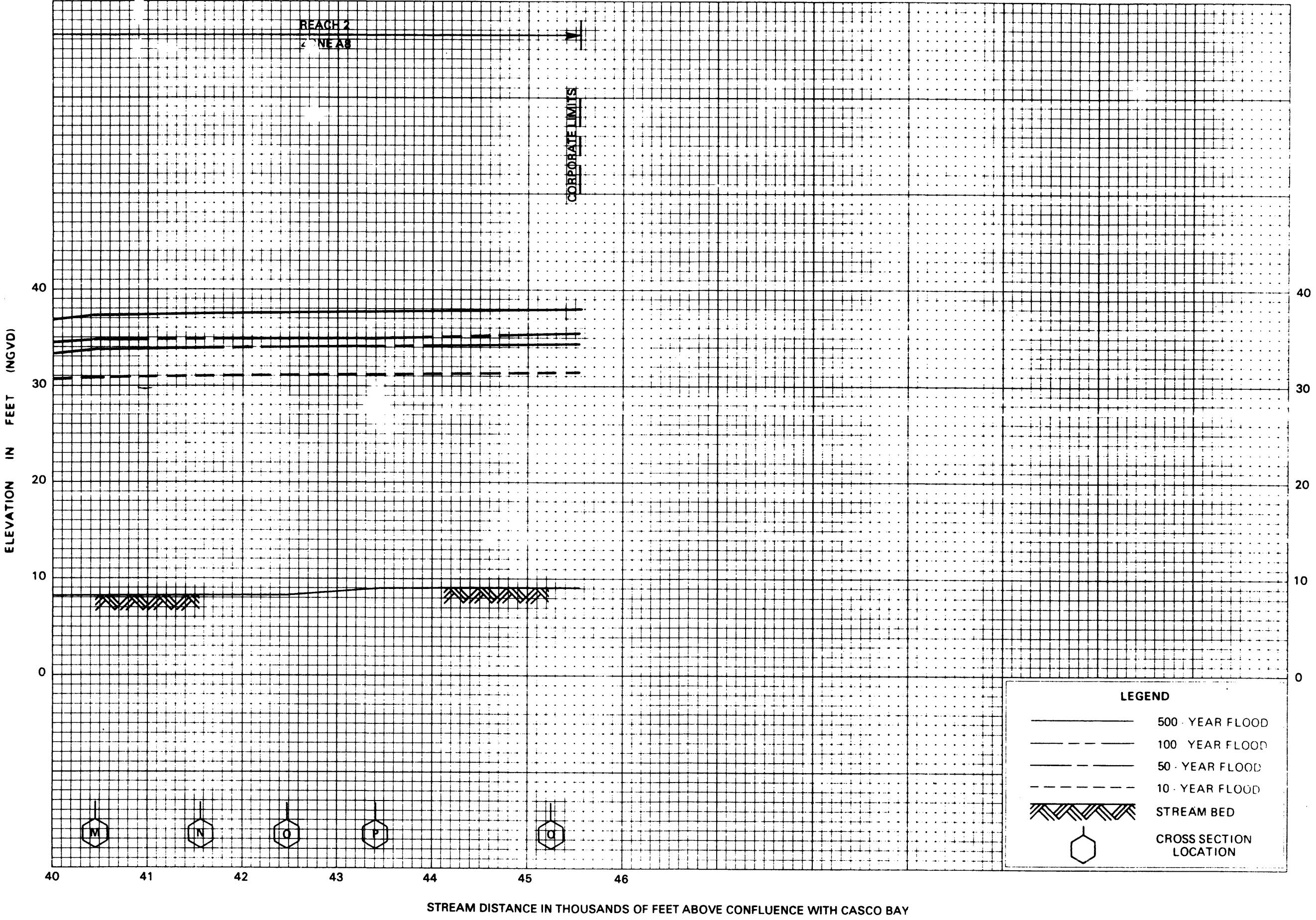


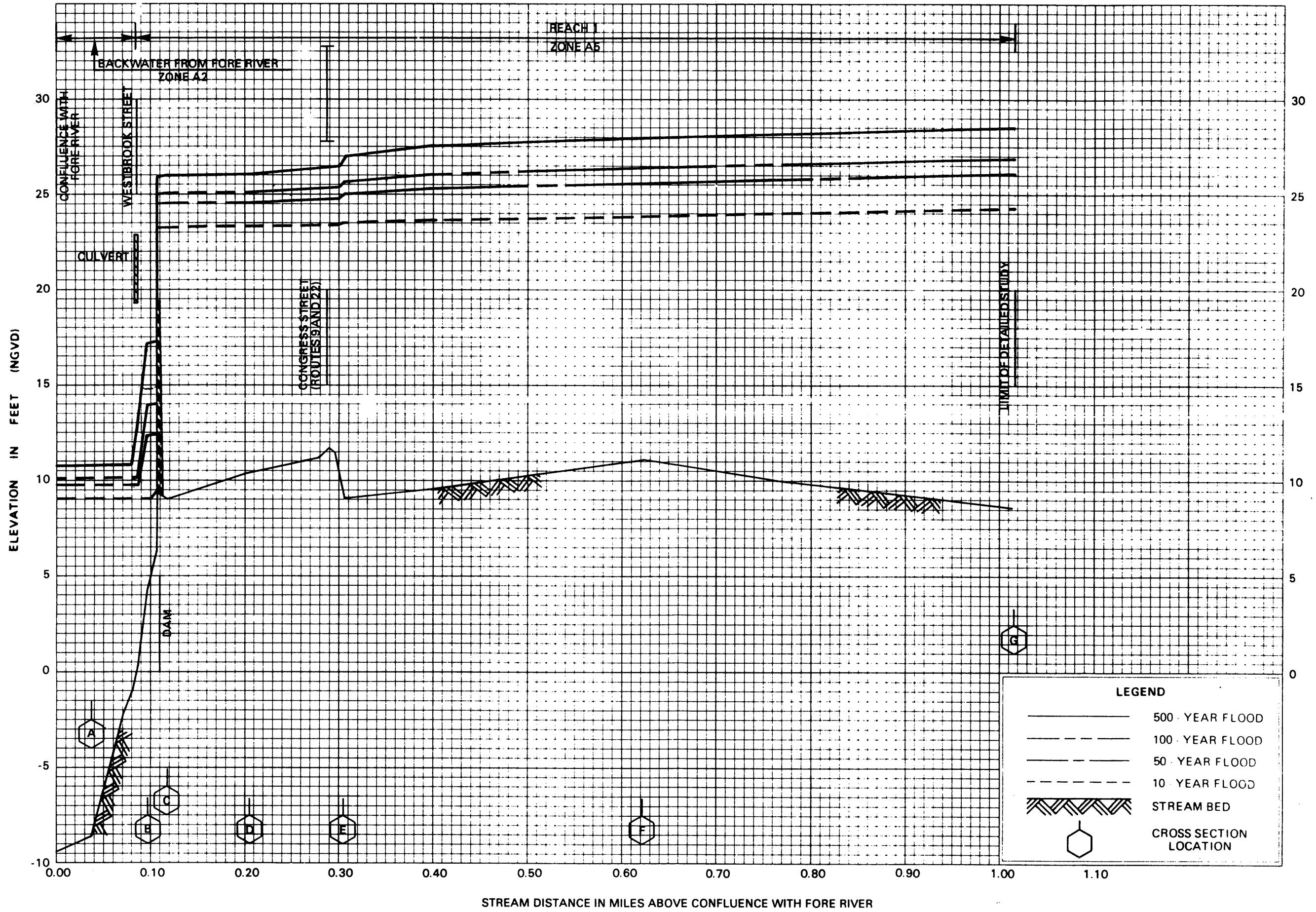
## PRESUMPSCOT RIVER

### FLOOD PROFILES

CITY OF PORTLAND, ME  
(CUMBERLAND CO.)

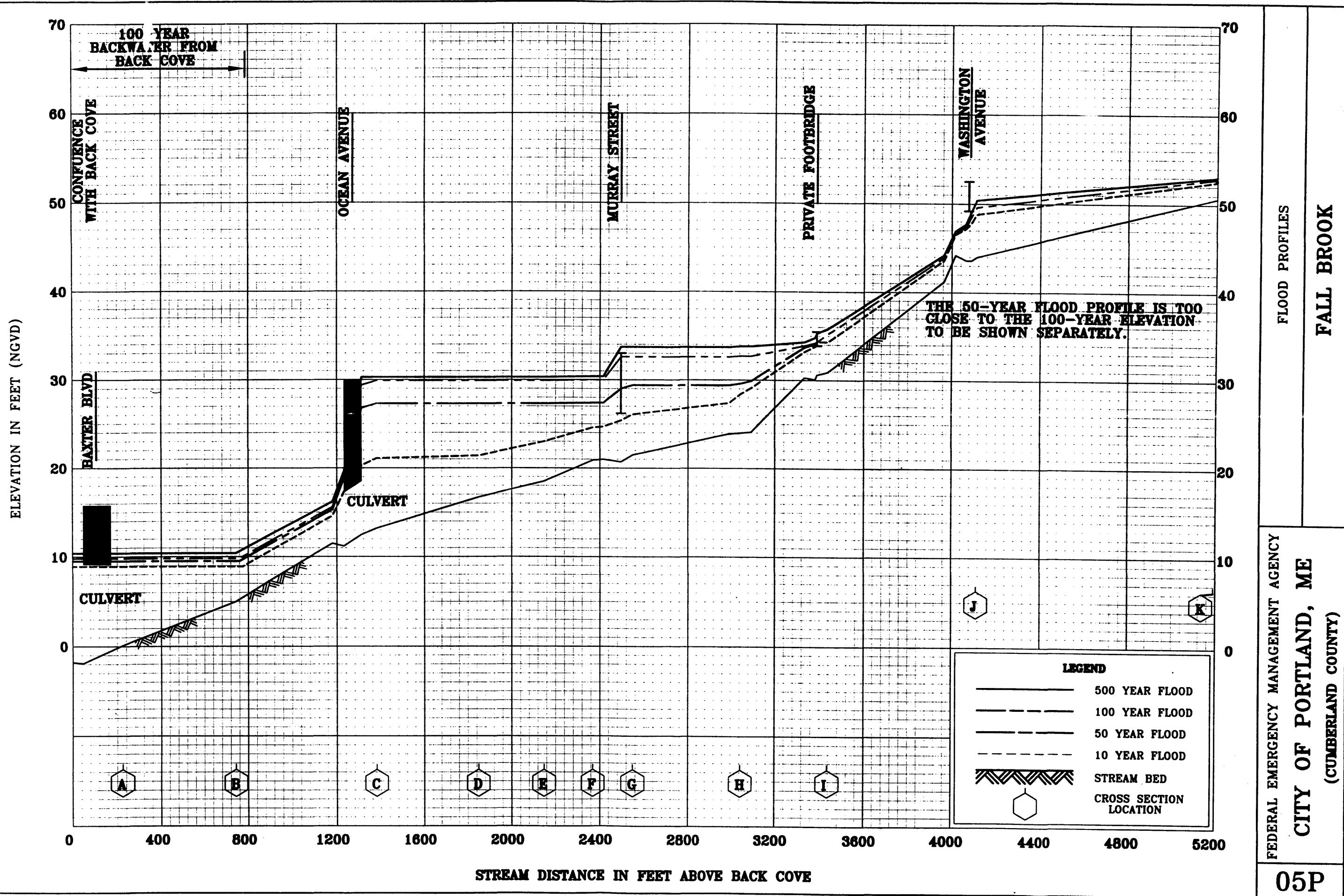
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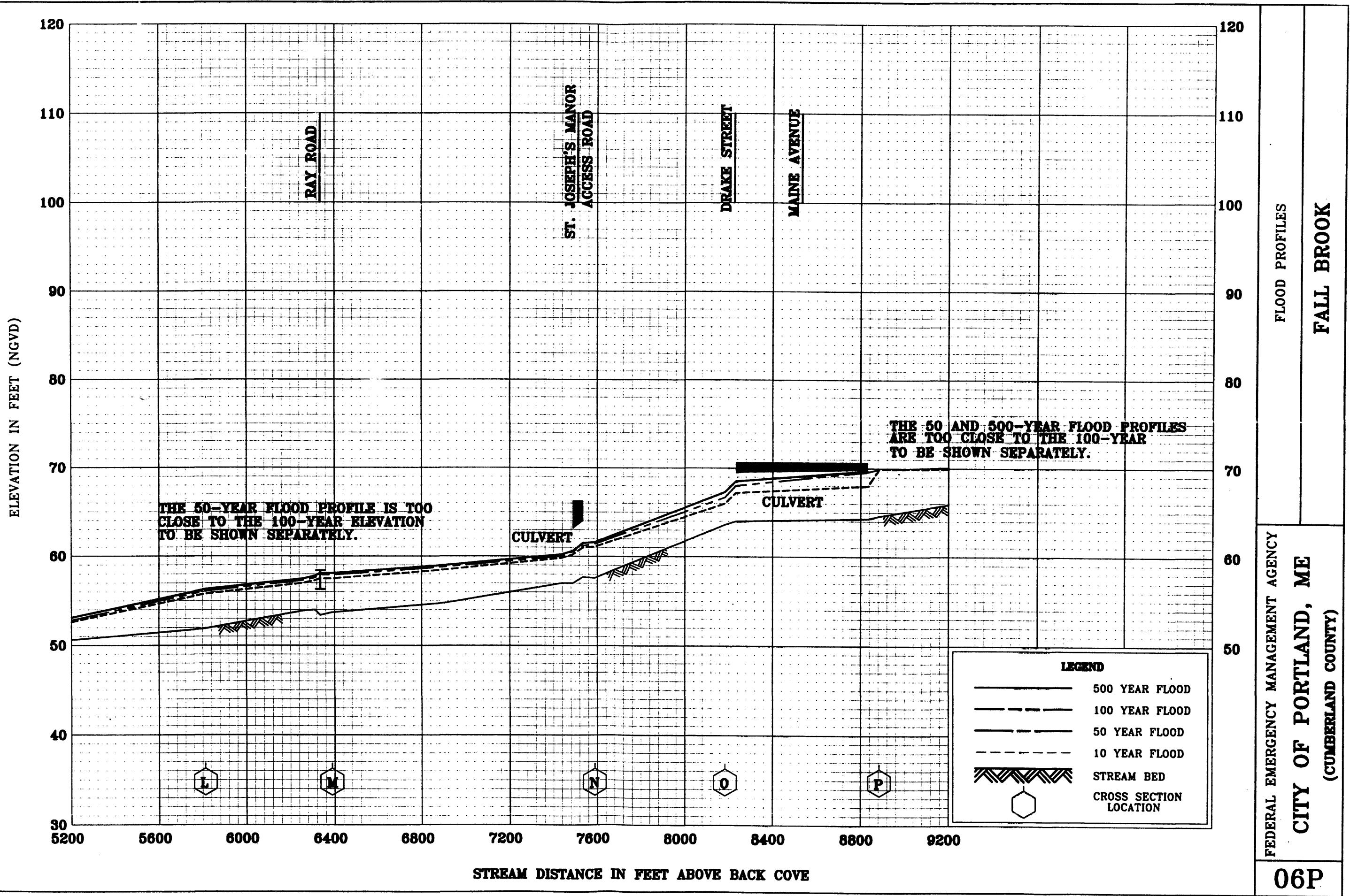




**CITY OF PORTLAND, ME**  
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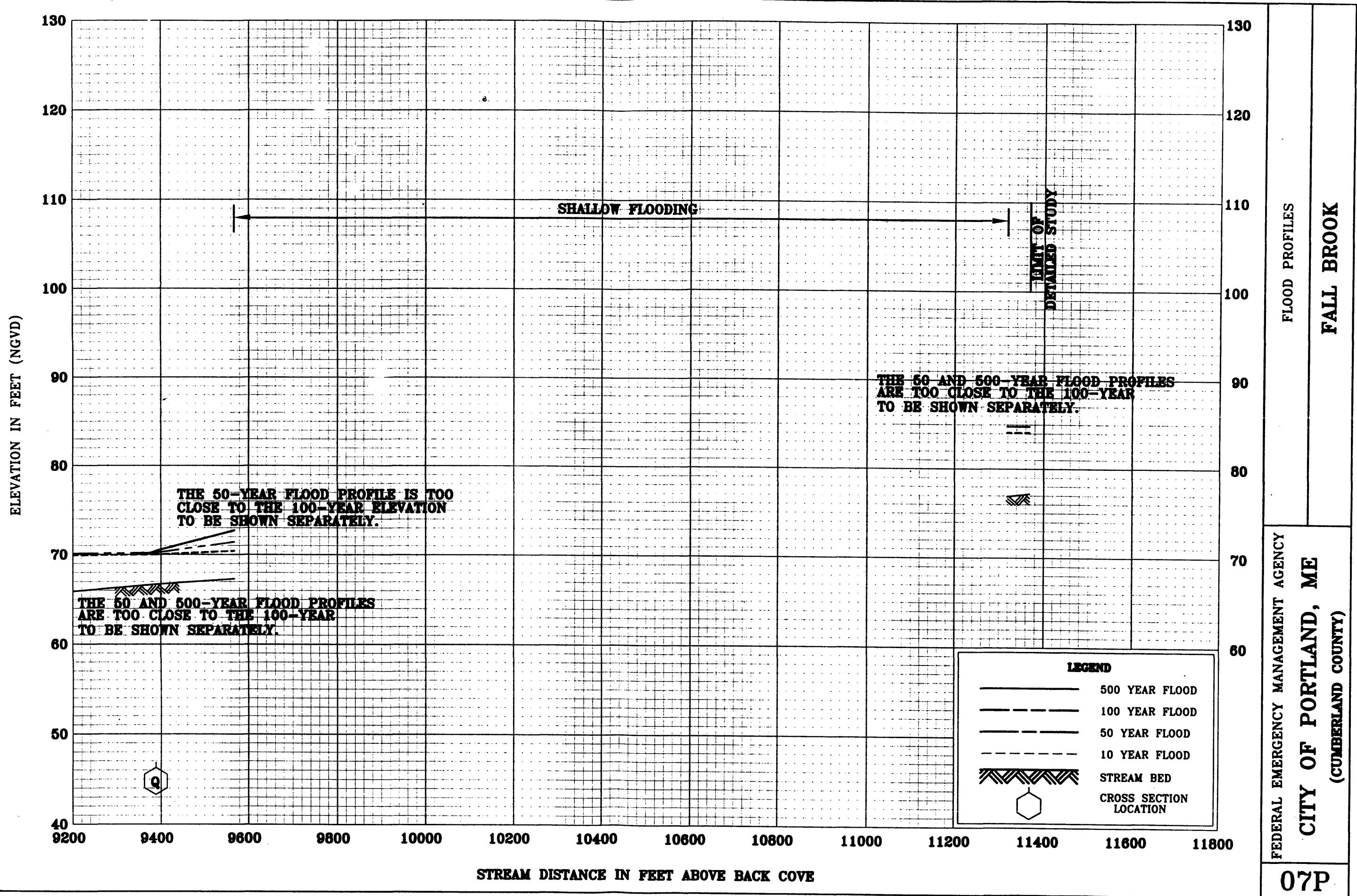
FEDERAL EMERGENCY MANAGEMENT AGENCY





FEDERAL EMERGENCY MANAGEMENT AGENCY  
CITY OF PORTLAND, ME  
(CUMBERLAND COUNTY)

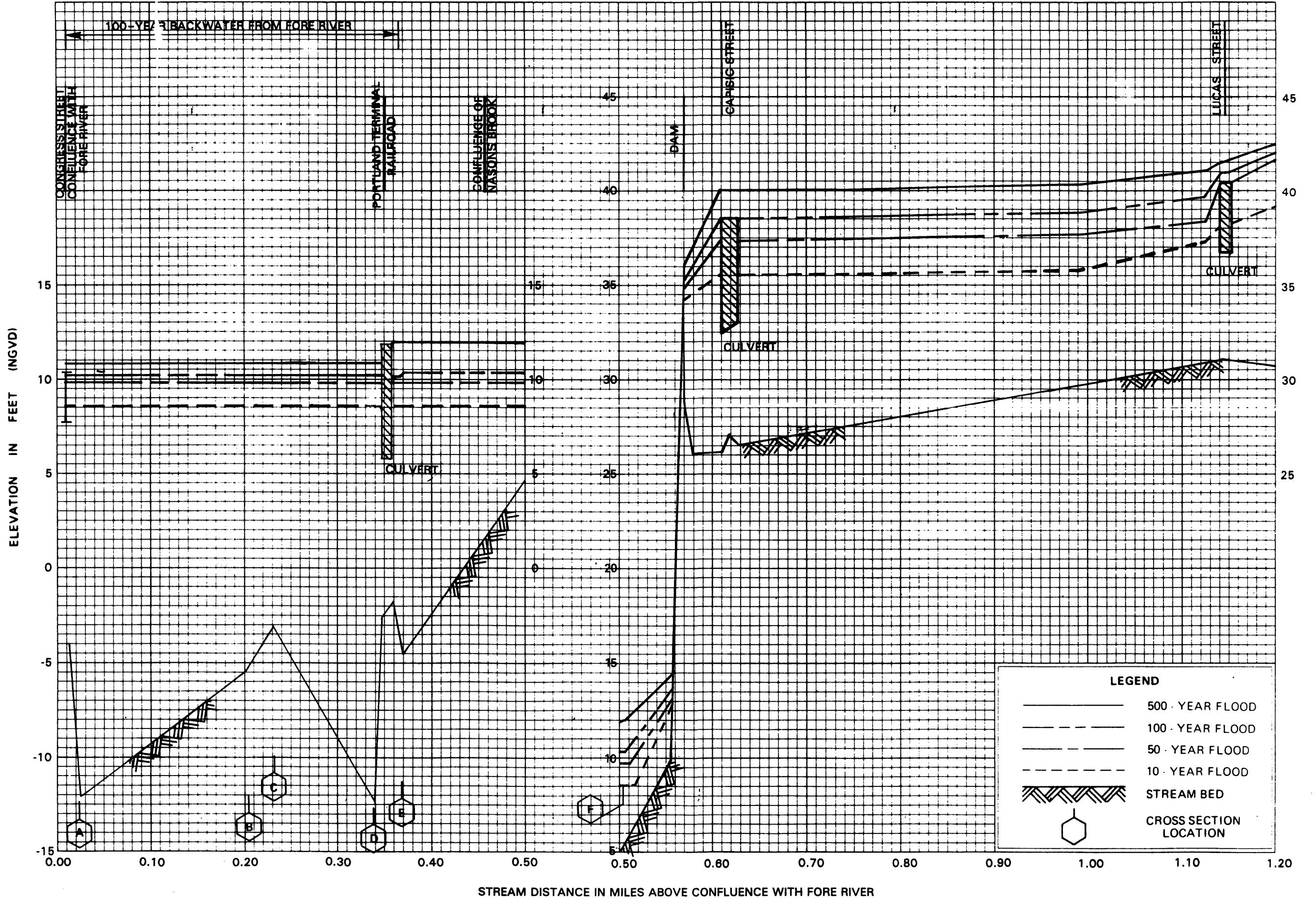
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**FEDERAL EMERGENCY MANAGEMENT AGENCY**  
**CITY OF PORTLAND, ME**  
(CUMBERLAND COUNTY)

**FLOOD PROFILES**

**07P**



**FEDERAL EMERGENCY MANAGEMENT AGENCY  
(CUMBERLAND CO.)**

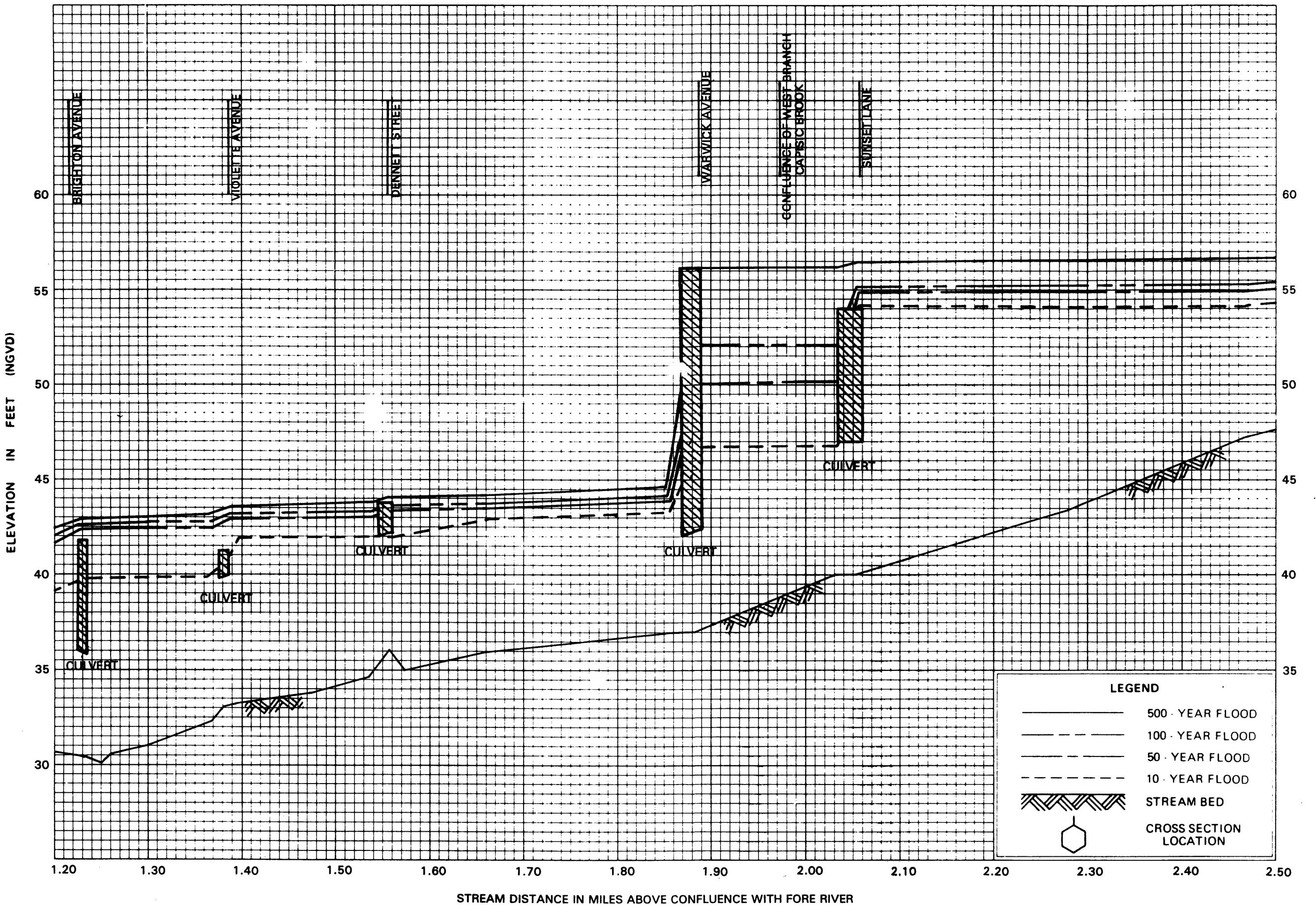
**CITY OF PORTLAND, ME**

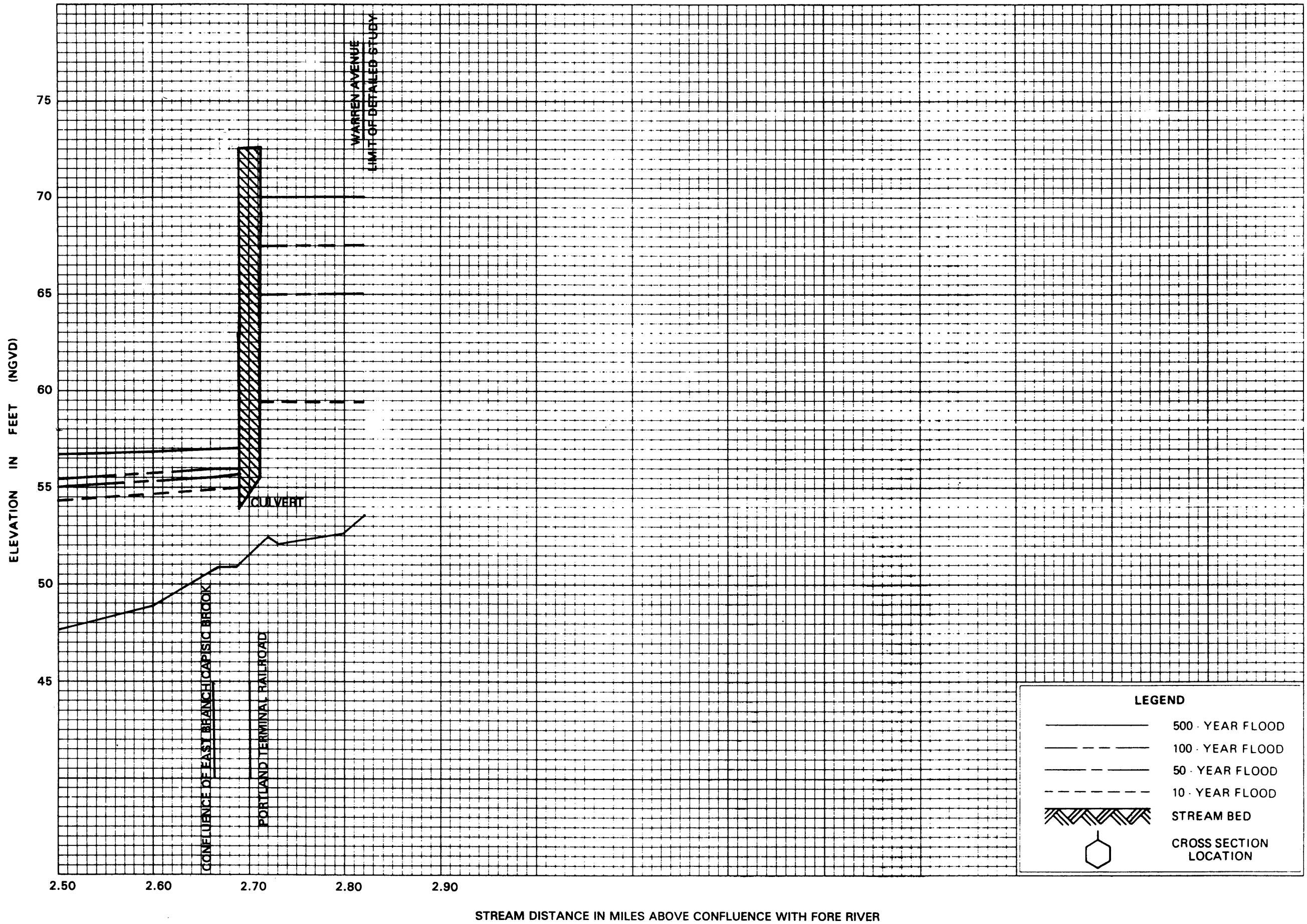
## CAPISIC BROOK

### FLOOD PROFILES

**CITY OF PORTLAND, ME**  
(CUMBERLAND CO.)

FEDERAL EMERGENCY MANAGEMENT AGENCY



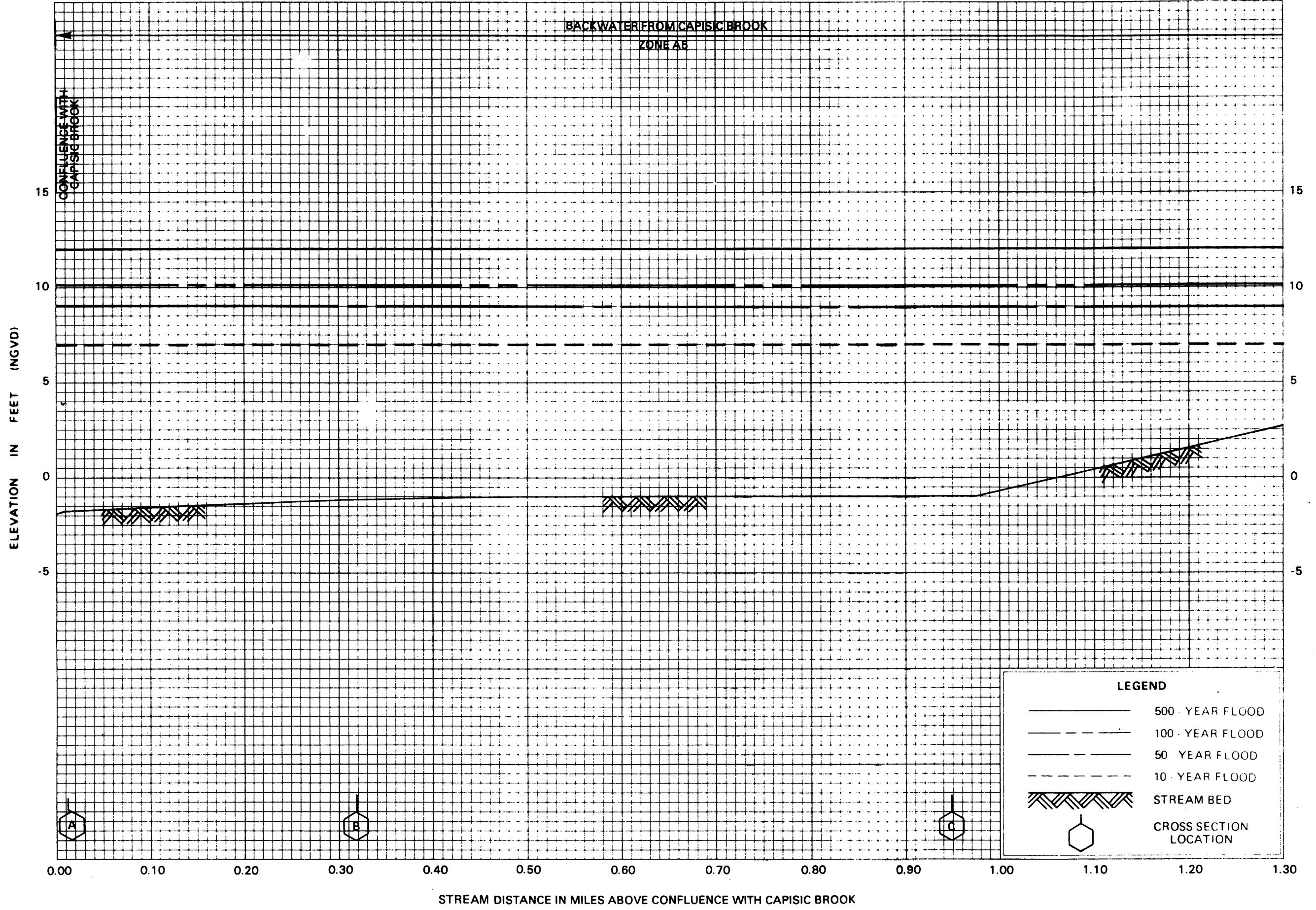


**CITY OF PORTLAND, ME**  
(CUMBERLAND CO.)

**FLOOD PROFILES**

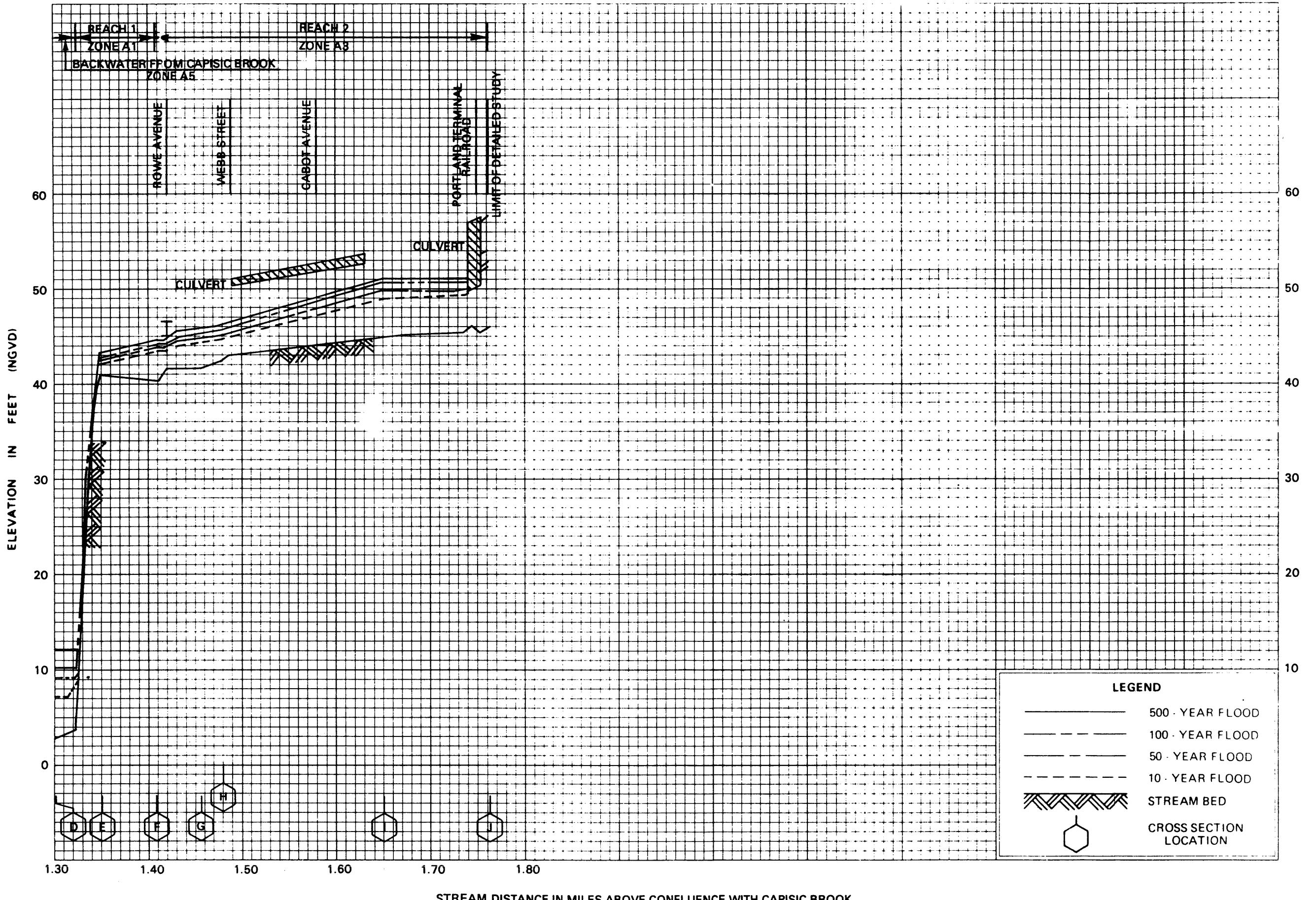
**CAPISIC BROOK**

FEDERAL EMERGENCY MANAGEMENT AGENCY



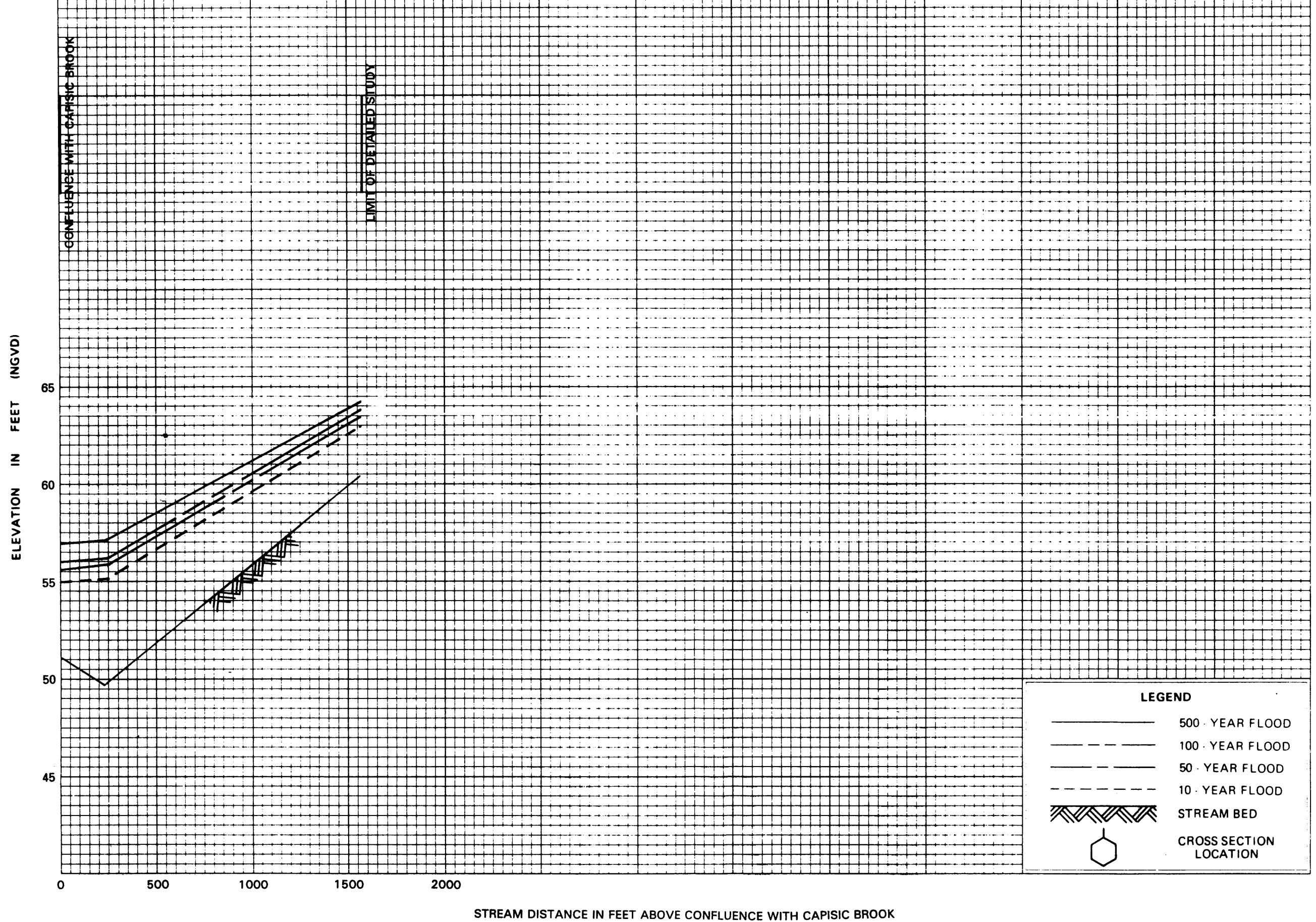
FLOOD PROFILES  
NASONS BROOK

CITY OF PORTLAND, ME  
(CUMBERLAND CO.)



**CITY OF PORTLAND, ME**  
(CUMBERLAND CO.)

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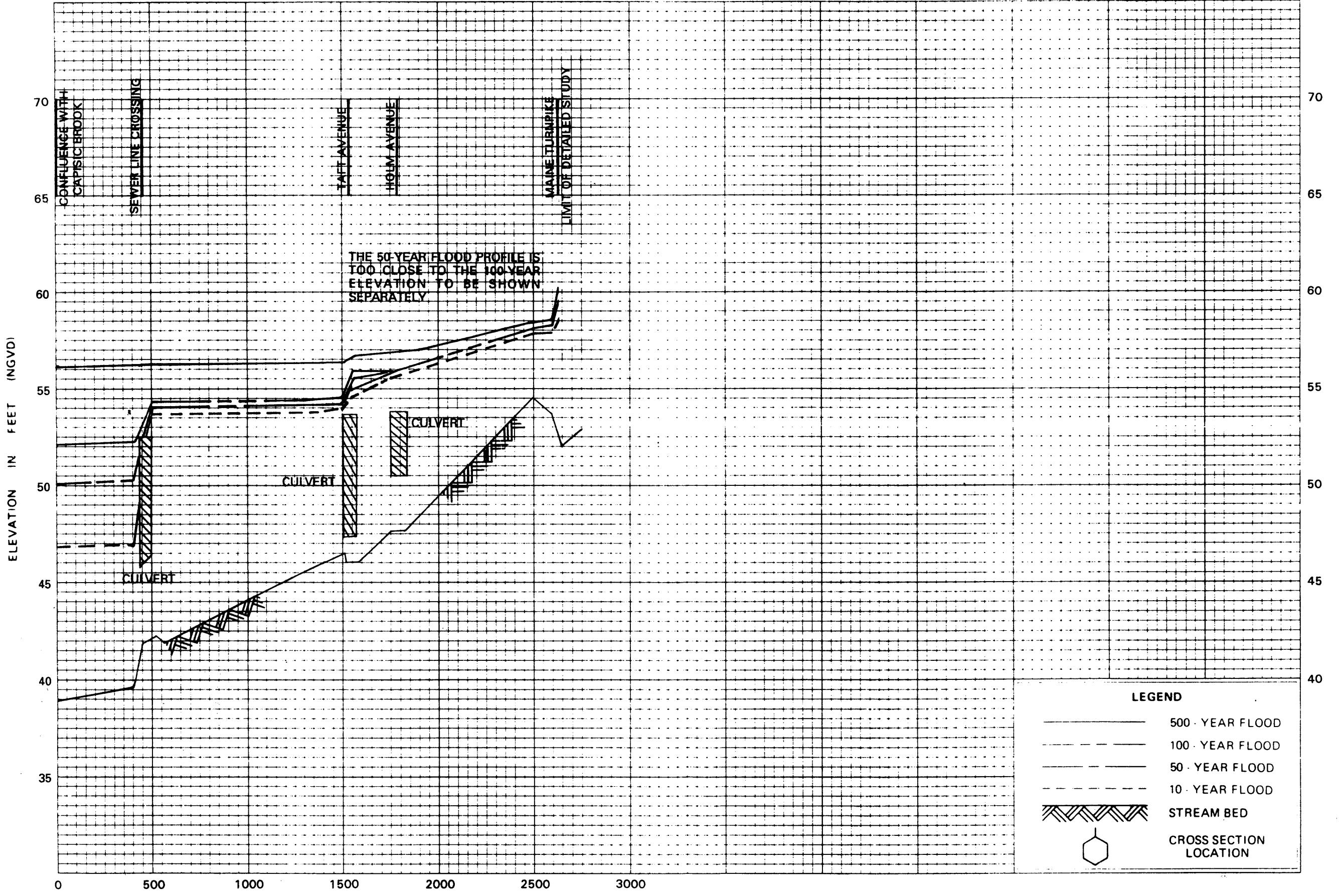


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## CITY OF PORTLAND, ME

### FLOOD PROFILES

#### EAST BRANCH CAPISIC BROOK



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